CMFRI Training Manual Series No.73/2026

Manual of the HRD Training Programme on

Sustainable Marine Tourism & Fisheries Heritage of Kerala

Marine Biodiversity and Environment Management Division
ICAR – Central Marine Fisheries Research Institute, Kochi

80 Years of ICAR-CMFRI

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FOREWORD

Kerala's relationship with the sea is not a chapter in the state's story. It is the spine the whole story is built on. Along nearly six hundred kilometres of coast, and through the quiet backwaters that thread inland behind it, generations of fishers, farmers, boat builders and traders have shaped a way of life in constant conversation with tides, monsoons and migrating shoals. Today, a growing number of visitors come to Kerala hoping to understand that conversation for themselves, and it is the tourist guide, more than any brochure or signboard, who makes that understanding possible.

This manual was written for that guide. It gathers, in one place, the working knowledge that ICAR–Central Marine Fisheries Research Institute has built over decades of studying Kerala's coast, its oceanography and tides, its fish and fisheries, its corals, mangroves and marine mammals, its seabirds and backwaters, its aquaculture farms and export harbours, and, more recently, its emerging dive sites. Each chapter was shaped by scientists who spend their working lives in exactly these habitats, and then rebuilt, chapter by chapter, into a single, consistent form: grounded enough to be trusted, and plain enough to be spoken aloud on a moving boat to a group of curious strangers.

What this manual asks of its reader is not memorisation but translation, the particular skill of turning a fact about salinity, or a species' conservation status, or a fishing community's history, into a sentence that makes a visitor look twice at the water they are passing over. Done well, that translation does something larger than entertain: it turns a boat ride into an act of attention, and attention, sustained over enough visitors and enough years, is what protects a coastline. A guide who can explain why a mangrove root matters, or why a particular beach carries a Blue Flag, is doing conservation work as surely as any scientist in the field.

We offer this manual, then, in the hope that it earns its place in a guide's kit bag alongside the tide table and the binoculars not as a document to be filed away, but as a companion to be returned to, argued with, and worn soft at the edges with use. To everyone who contributed a chapter, a table, a photograph or a correction, our sincere thanks. And to the guide holding this manual on a Kerala shoreline: the coast is in good company.

Grinson George
Director, ICAR-CMFRI

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CHAPTER 1

OCEANOGRAPHY

Physical and Biological Oceanography for Tour Guides

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> **How to Use This Chapter:** *This chapter introduces the physical and biological workings of the ocean- zonation, tides, currents, waves, salinity, colour and productivity, and the marine food web - grounded throughout in examples from Kerala's own coast. It opens with the coastline and fishing communities of Kerala, moves through the physics any guide needs to explain what's happening in the water beneath a boat, and closes with the climate phenomena reshaping that coast today.*

In This Chapter

1. Introduction & Coastal Context

India's coastline has recently been re-estimated at 11,098.81 km, revised in 2024 from the older figure of 7,516.6 km using finer-scale, fractal mapping, of which Kerala's maritime frontier measures 600.15 km (up from 569.7 km). This slender coast, a narrow strip of land pressed between the Arabian Sea and the Western Ghats, is where the people of Kerala have met the ocean for more than two thousand years. It is the natural doorway to the oceanography that follows.

A living coast

Kerala's shore runs through nine coastal districts namely Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur and Kasaragod, and is far more than a line of beach. It is a mosaic of sandy shores, rocky headlands, river mouths, estuaries, mud-flats and mangrove pockets, backed by the great chain of brackish backwaters and kayals (Vembanad, Ashtamudi, Sasthamkotta) that lie just inland. Ten rivers draining the Ghats meet the sea here, making this one of the most productive and densely settled shorelines in India.

The fishing community

Above all, the coast is a human landscape. Around 222 marine fishing villages line these 600 kilometres, supporting a marine fisherfolk population of roughly seven lakhs (about 6.1 lakh recorded in the CMFRI Marine Fisheries Census, 2010), with close to eight lakh people dependent on marine fishing and allied work such as net-making, curing, marketing and boat-building. The community is plural: Hindu fisherfolk (Arayas / Dheevara, Valans, Mukkuvas and Marakkans), Latin Catholic Christians long organised around the coastal church, and Muslim (Mappila) fishers together sharing the same sea across religious lines. Traditional village life was governed by the *Kada Kodi*, an informal fishers' council that settled disputes and regulated access to the sea, an early, community-based form of coastal governance that survives in places even today.

Continuity from the ancient world

Kerala's coast has been globally connected since antiquity. The ancient port of Muziris (near Kodungallur, with the excavated site at Pattanam) was, from before the Common Era, the foremost trading port on India's west coast, celebrated in Tamil Sangam poetry and in Graeco-Roman texts such as Pliny's *Natural History* and the *Periplus of the Erythraean Sea*. Riding the monsoon winds across the Arabian Sea, Roman, Greek, Arab, Jewish and Chinese traders came for black pepper and other spices, exchanging so much Roman coin that Roman writers complained of the drain of gold. When a catastrophic Periyar flood silted up Muziris around 1341 CE, the trade simply shifted south to Cochin (Kochi), which remains the coast's dominant port — the same commerce moving up and down the same short coast for two millennia.

European domination and after

The modern era opened when Vasco da Gama landed near Calicut, at Kappad, in 1498, forging the first direct sea route between Europe and the spice coast. The Portuguese, Dutch and British each contested the Malabar spice trade in turn, reshaping the ports, forts and fishing settlements along the shore. In the twentieth century the coast was transformed again: the Indo-Norwegian Project (1953), based at Neendakara-Sakthikulangara near Kollam and

Norway's first-ever foreign-aid venture, introduced motorised boats and modern nets. This sparked mechanisation, the shift from cotton to nylon, and the rise of the trawl and ring-seine fisheries with the great prawn-export boom of the following decades. Today the same coast carries mechanised harbours and export chains alongside traditional catamarans and dugout canoes, even as it confronts new pressures: coastal erosion, overfishing, and cyclones such as Ockhi (2017).

From Muziris to the mechanised harbour, the people of Kerala have read the sea's tides, currents, winds and productivity by instinct and inheritance.

2. Core Concepts & Environmental Dynamics

Zonation of the Ocean

The ocean covers about 71% of the Earth's surface and reaches depths of over 11,000 m in the deepest trenches. Conditions such as light, temperature, pressure, oxygen, and nutrient availability change from the coast to the deep sea and with increasing depth. Scientists divide the ocean into different zones, a process known as ocean zonation, to better understand the physical environment and the distribution of marine life.

Ocean zonation can be classified into three main types:

- **Horizontal zonation** is based on distance from the shore (littoral, neritic, and oceanic zones).
- **Vertical (pelagic) zonation** is based on water depth (epipelagic to hadal zones).
- **Benthic zonation** is based on the seafloor environment (littoral to hadal benthic zones).

Horizontal zonation

(a) Littoral (Intertidal) Zone

The littoral zone is the region between the high-tide mark and the low-tide mark. This area is alternately covered by seawater during high tide and exposed to air during low tide.

(b) Neritic Zone

The neritic zone extends from the low-tide mark to the edge of the continental shelf, usually reaching depths of about 200 m. Since sunlight reaches the entire water column, photosynthesis occurs throughout this zone. Nearly 90% of the world's marine fish catch comes from the neritic zone because of its high biological productivity.

(c) Oceanic Zone

Beyond the continental shelf lies the oceanic zone, also called the open ocean. This zone covers almost 90% of the ocean's area.

Vertical (pelagic) zonation

The epipelagic (0-200 m) or sunlight zone receives enough sunlight for photosynthesis and supports most marine productivity. Below it, the mesopelagic (200-1,000 m) or twilight zone receives very little light. The bathypelagic (1,000-4,000 m), abyssopelagic (4,000-6,000 m), and hadal (>6,000 m) zones are completely dark, cold, and experience extremely high pressure.

Marine organisms are specially adapted to each zone. Coral reefs, seagrasses, and phytoplankton dominate shallow waters, while deep-sea organisms possess adaptations such as bioluminescence, slow metabolism, and pressure tolerance. Ocean zonation influences biodiversity, fisheries, nutrient cycling, and global climate, making it a fundamental concept in oceanography.

Benthic Zonation

While vertical zonation describes the water column, benthic zonation classifies the ocean floor based on depth and location. Organisms living on or within the seabed are called benthos. The benthic zone is divided into:

- **Littoral benthic zone** is the seabed in the intertidal region, exposed at low tide and submerged at high tide.
- **Sublittoral benthic zone** is the seabed beneath the continental shelf, rich in corals, seagrasses, shellfish, and many commercially important fishes.
- **Bathyal benthic zone** is the continental slope, roughly 200–4,000 m, with limited light and cooler temperatures.
- **Abyssal benthic zone** is the flat abyssal plains (about 4,000–6,000 m), characterised by soft sediments, low food availability, and slow-growing organisms.
- **Hadal benthic zone** is the floors of deep ocean trenches (>6,000 m), inhabited by specialised worms, crustaceans, microorganisms, and other pressure-adapted species.

Note: *benthic and pelagic zones use slightly different depth conventions in the literature; the boundaries above are harmonised with the pelagic scheme used earlier so the two are consistent.*

Tides

Tides are the regular and periodic rise and fall of sea level caused primarily by the gravitational attraction of the Moon and the Sun, together with the Earth's rotation. Although both celestial bodies exert gravitational forces on the Earth, the Moon has a much greater influence on tides because of its closer proximity. Unlike ocean waves, which are generated mainly by wind, tides are the vertical movement of seawater driven by these astronomical forces, producing alternating periods of high tide (rise in sea level) and low tide (fall in sea level). The interval between two successive high tides is approximately 12 hours and 25 minutes, resulting in two high tides and two low tides in many coastal regions during a lunar day. As one of the most predictable natural phenomena, tides play a fundamental role in shaping coastal environments, influencing navigation, sustaining marine ecosystems and fisheries, and providing a reliable source of renewable tidal energy.

Tide-Generating Forces

Tides result from two opposing forces:

- **Gravitational force**, which attracts ocean water toward the Moon and the Sun.
- **Centrifugal force**, produced by the Earth-Moon system revolving around a common centre of mass (barycentre).

These forces create two tidal bulges: one on the side facing the Moon (direct tidal bulge) and another on the opposite side (opposite tidal bulge). As the Earth rotates through these bulges, most places experience two high tides and two low tides each day.

Tidal Bulges

A tidal bulge is a region where seawater accumulates because of the balance between gravitational and centrifugal forces. The bulge facing the Moon is created mainly by the Moon's gravitational pull; the bulge opposite the Moon is created mainly by centrifugal force. The Earth rotates beneath these nearly fixed bulges, causing regular tidal changes.

High Tide and Low Tide

High tide occurs when seawater reaches its maximum height along the coast due to a tidal bulge. Low tide occurs when seawater reaches its lowest level between two tidal bulges. The difference in height between high tide and low tide is called the tidal range.

Flood Tide and Ebb Tide

The flood tide is the period during which sea level rises from low tide to high tide; the ebb tide is the period during which sea level falls from high tide to low tide. These tidal currents transport nutrients, sediments, larvae, and plankton within coastal waters.

Types of Tides: Relative Positions of Earth, Moon, and Sun

A. Spring Tide

Spring tides occur during the new moon and full moon, when the Earth, Moon, and Sun are aligned in a straight line. The gravitational forces of the Moon and the Sun reinforce each other, producing the highest high tides, the lowest low tides, and the maximum tidal range.

B. Neap Tide

Neap tides occur during the first- and third-quarter phases of the Moon. The Sun and Moon are at right angles relative to the Earth, so their gravitational effects partially cancel, giving lower high tides, higher low tides, and the minimum tidal range.

Types of Tides: Daily Occurrence

- **Diurnal tide:** one high tide and one low tide every lunar day; common in parts of the Gulf of Mexico and Southeast Asia.
- **Semidiurnal tide:** two high tides and two low tides of nearly equal height each day; the most common tidal pattern worldwide.
- **Mixed tide:** two high tides and two low tides each day, but with unequal heights; common along the Pacific coast of North America.

Tidal Range

The tidal range is the vertical difference between high tide and low tide. It is classified as microtidal (less than 2 m), mesotidal (2-4 m), and macrotidal (greater than 4 m). Some regions, such as the Bay of Fundy (Canada), experience tidal ranges exceeding 15 m, among the highest in the world.

Tidal Bore

A tidal bore is a steep, fast-moving wave that travels upstream in a river or estuary when an incoming tide is forced into a narrow, shallow channel. It requires a large tidal range, a funnel-shaped estuary, and a shallow river.

Ocean Currents

Ocean currents are continuous, predictable, directional movements of seawater driven by gravity, wind friction, and variations in water density. They function much like giant rivers flowing within the ocean, moving vast amounts of water and redistributing heat, salt, nutrients, and organisms across the globe.

1. Primary Types of Ocean Currents

(a) Surface Currents

These occur in the upper 400 metres of the ocean, representing approximately 10% of the ocean's total volume. They are driven by global wind systems (such as trade winds and westerlies) and the Coriolis Effect (the apparent deflection of moving objects caused by Earth's rotation to the right in the Northern Hemisphere and to the left in the Southern Hemisphere). Surface currents organise into massive circular loop systems known as ocean gyres (e.g., North Atlantic Gyre, South Pacific Gyre).

(b) Deep Ocean Currents (Thermohaline Circulation)

These operate below 400 metres depth, comprising roughly 90% of the world's ocean water. They are driven by water density gradients resulting from variations in temperature ('thermo') and salinity ('haline'). In the global conveyor belt, cold, high-salinity water sinks near polar regions and moves slowly along ocean basins before rising back towards the surface through upwelling in warmer regions.

2. Key Drivers of Ocean Currents

- **Solar heating:** differential solar radiation warms and expands water near the equator, establishing subtle surface slope gradients.
- **Wind drag**: prevailing planetary winds transfer momentum to the ocean surface through frictional force, propelling surface waters.
- **Coriolis effect**: Earth's rotation deflects moving fluid masses, redirecting surface flow and shaping gyre structures.
- **Density differences:** temperature shifts and freshwater fluxes (evaporation, precipitation, sea-ice formation and melting) alter water-mass density.
- **Bathymetry & coastlines**: seafloor topography (continental shelves, ridges, trenches) and landmass boundaries alter and redirect current paths.

Major Currents of the Arabian Sea and Indian Ocean

Current	Temperature	Region	Major impact & characteristics
Gulf Stream	Warm	North Atlantic	Transports tropical heat to Western Europe, moderating regional climate.
Kuroshio Current	Warm	North-West Pacific	Transports warm equatorial water northward past Taiwan and Japan.
California Current	Cold	Eastern Pacific	Cooler coastal stream promoting strong upwelling and rich ecosystems.

Current	Temperature	Region	Major impact & characteristics
Humboldt (Peru) Current	Cold	South-East Pacific	Highly productive upwelling system supporting massive fisheries.
Antarctic Circumpolar Current	Cold	Southern Ocean	Circum-global current connecting major oceans; largest volume transport.

Closer to home, the West India Coastal Current (WICC) reverses with the monsoon: it flows equatorward (south) during the winter (November–February) and poleward (north) during the summer monsoon (June–September), driven by monsoon wind reversal and coastal upwelling/downwelling. This seasonal reversal, along with the broader Indian Ocean monsoon current system, shapes when and where Kerala's coastal upwelling and its fisheries productivity peaks each year.

4. Ecological and Climatic Significance

5. **Climate regulation**: ocean currents act as a global heat-distribution system, regulating planetary temperatures and preventing extreme latitudinal climate divides.
6. **Nutrient cycling & upwelling**: wind-driven coastal and equatorial upwelling lifts cold, nutrient-rich deep waters into the photic zone, fuelling primary productivity and supporting commercial fisheries.
7. **Biological migration & transport**: currents transport marine organisms, including fish larvae, sea turtles, across vast distances, facilitating life-cycle stages and genetic connectivity.

Ocean Waves

Ocean waves are energy passing through seawater, causing the water to move in a circular, orbital motion. Contrary to appearance, the water itself does not travel long distances across the ocean; rather, the energy propagates through the water column.

1. Anatomy of an Ocean Wave

- **Crest** is the highest point of the wave above the still-water level.
- **Trough** is the lowest point of the wave below the still-water level.
- **Wave height (H)** is the vertical distance between the crest and the neighbouring trough.
- **Wavelength (λ)** is the horizontal distance between two successive crests or troughs.
- **Wave period (T)** is the time (in seconds) required for two consecutive crests to pass a fixed reference point.
- **Frequency (f)** is the number of wave crests passing a fixed point per second (f = 1/T).
- **Wave base** is the depth below the surface where wave-induced orbital motion ceases, equal to approximately half the wavelength (λ/2).

2. Water Particle Motion: Orbital Circulation

As a wave propagates, individual water particles move in vertical circular paths called orbital paths. At the surface, water particles describe larger circular orbits, moving forward at the crest, downward on the trailing slope, backward in the trough, and upward on the leading

edge. The orbital radius decreases exponentially with depth, and below the wave base (depths greater than $\lambda/2$) the water remains undisturbed by surface wave dynamics.

3. Primary Drivers and Wave Generation

- **Wind forcing**: frictional drag from wind generates capillary waves, which grow into wind waves and long-period swells depending on wind speed, duration, and fetch.
- **Gravitational forces**: the gravitational pull of the Moon and Sun creates tides, which are extremely long-period waves spanning entire ocean basins.
- **Geological displacement**: submarine earthquakes, volcanic eruptions, or coastal landslides displace large water masses, initiating tsunamis.
- **Atmospheric fluctuations**: rapid changes in atmospheric pressure and severe storm systems generate storm surges and meteotsunamis.

4. Main Types of Ocean Waves

Wave type	Cause / origin	Typical wavelength	Typical period
Capillary waves	Light wind drag; restored by surface tension	< 1.7 cm	< 0.1 second
Wind waves	Local storm winds in active fetch areas	60 – 150 m	1 – 10 seconds
Swells	Mature wind waves travelling beyond origin area	100 – 500 m	10 – 20 seconds
Tsunamis	Submarine earthquakes, landslides, or volcanic events	100 – 200 km	10 – 60 minutes
Tides (very long-period waves)	Gravitational attraction of Moon & Sun	~ half Earth circumference	12.4 or 24.8 hours

Note: *the older term "tidal wave" is a misnomer and is often wrongly used for a tsunami. Tides are best described as extremely long-period waves; tsunamis are quite separate, being generated by geological displacement.*

5. Wave Behavior Near Shore (Deep to Shallow Water)

- **Seafloor interaction**: when water depth decreases below the wave base (depth < $\lambda/2$), bottom friction compresses circular orbits into elliptical trajectories.
- **Shoaling dynamics**: as energy is confined to shallower water, wave celerity decreases, wavelength shortens, and wave height increases markedly.
- **Wave breaking (surf zone)**: when wave steepness exceeds $H/\lambda > 1/7$, or wave height reaches ~0.78 of water depth, the wave collapses into breakers (spilling, plunging, or surging).

Salinity

Salinity is a fundamental property of seawater, defined as the total amount of dissolved inorganic solids (salts) in a given volume of water. It plays a critical role in driving global ocean currents, regulating climate, and dictating the distribution of marine life.

Composition of Sea Salt

While seawater contains almost every element found on Earth in trace amounts, six major ions account for over 99% of all dissolved solids in the ocean. The average salinity of the open ocean is approximately 35 parts per thousand (ppt). This means that in 1,000 grams of seawater there are 35 grams of dissolved salts and 965 grams of pure water.

> **Forchhammer's Principle (the Principle of Constant Proportions):** *regardless of how much the total salinity varies from one region of the ocean to another, the absolute chemical ratio of the major conservative ions to one another remains virtually constant throughout the global ocean.*

Major Chemical Ions in Seawater

Dissolved inorganic ion	Approx. % of total salt
Chloride (Cl^-)	55.0%
Sodium (Na^+)	30.6%
Sulfate (SO_4^{2-})	7.7%
Magnesium (Mg^{2+})	3.7%
Calcium (Ca^{2+})	1.2%
Potassium (K^+)	1.1%

Note: *bicarbonate (HCO_3^-; ~0.4%) is the principal remaining (minor) ion, and is sometimes listed among the major constituents.*

Factors Controlling Salinity

Ocean salinity is not uniform everywhere; it fluctuates based on the balance between processes that add freshwater and those that remove it.

Processes that decrease salinity (dilution)

- **Precipitation**: rain and snow add fresh water directly to the ocean surface.
- **River runoff**: large river systems pour massive volumes of fresh water into coastal zones (e.g., the Bay of Bengal).
- **Melting ice**: melting glaciers and sea ice release fresh water back into the marine system.

Processes that increase salinity (concentration)

- **Evaporation**: solar radiation vaporises pure water, leaving the dissolved salts behind. This significantly elevates salinity in arid regions such as the Red Sea and the Arabian Sea.

- **Sea-ice formation**: when seawater freezes at the poles, salt is excluded from the forming ice crystal lattice in a process called brine rejection, leaving the surrounding unfrozen water highly saline and dense.

Vertical Distribution: The Halocline

Salinity varies not just geographically, but also with depth. The surface zone typically experiences the highest variability due to weather, evaporation, and runoff. The halocline is a distinct subsurface layer where salinity changes rapidly with depth. In high latitudes (polar regions), surface salinity is low due to melting ice and precipitation, so the halocline is a zone where salinity increases with depth; in low latitudes (tropics), surface salinity is high due to intense evaporation, so salinity decreases through the halocline until it stabilises. Below the halocline, the deep ocean is remarkably uniform, with salinity staying around 34.5 to 35 ppt globally.

Physical and Ecological Importance

Density and thermohaline circulation: salinity directly influences the density of water. Higher salinity equals higher density. When high-salinity water is also chilled near the poles, it becomes exceptionally dense and sinks. This sinking drives the deep-water limb of the **Global Ocean Conveyor Belt**, which distributes heat and nutrients across the planet.

Osmoregulation in marine organisms: salinity dictates how marine life manages water balance. Most marine invertebrates are osmoconformers (their internal salinity matches the environment), while most marine bony fish are osmoregulators. Because their bodies are less salty than the surrounding ocean, marine fish constantly lose water through their gills via osmosis, requiring them to drink large amounts of seawater and actively excrete excess salt through specialised cells.

Ocean Colour and Marine Productivity

The ocean appears blue when viewed from space or from the coast, but its colour is not always the same. Depending on the location and environmental conditions, seawater may appear deep blue, green, turquoise, brown, or even reddish. These variations provide valuable information about the physical, chemical, and biological properties of seawater. Scientists use changes in ocean colour to study the distribution of phytoplankton, suspended sediments, dissolved organic matter, and water quality. Today, satellite observations of ocean colour have become one of the most important tools for monitoring marine ecosystems and estimating biological productivity over the entire globe.

Marine productivity refers to the rate at which marine organisms, particularly phytoplankton, produce organic matter through photosynthesis. It forms the foundation of marine food webs and supports fisheries, biodiversity, and the global carbon cycle. Ocean colour and marine productivity are closely linked because changes in phytoplankton abundance directly influence the colour of seawater.

What is Ocean Colour?

Ocean colour is the colour of sunlight that is reflected or scattered back from the ocean surface after interacting with water molecules and substances suspended or dissolved within seawater. Contrary to common belief, the ocean is not simply blue because it reflects the sky; rather, the colour of seawater results from the interaction of sunlight with water and the

materials it contains. Pure seawater strongly absorbs the longer wavelengths of visible light (red, orange, and yellow) while scattering shorter blue wavelengths, so the open ocean usually appears blue. The presence of phytoplankton, suspended sediments, coloured dissolved organic matter (CDOM), and other particles modifies how light is absorbed and scattered, causing the ocean to appear green, brown, or other colours.

Factors Affecting Ocean Colour

- **Water molecules**: pure water absorbs red light more efficiently than blue, so blue wavelengths are scattered back to the observer, giving clear ocean water its deep blue colour.
- **Phytoplankton** contain chlorophyll-a, which absorbs blue and red light for photosynthesis while reflecting green; high concentrations make water appear green, usually indicating higher biological productivity.
- **Suspended sediments** like sand, silt and clay carried by rivers scatter sunlight, making water appear brown, yellow, or muddy near river mouths, estuaries, and coastlines.
- **Coloured dissolved organic matter (CDOM)**: organic compounds from decomposition absorb blue light, giving seawater a yellowish or brownish appearance, especially in estuaries.
- **Water depth and bottom reflectance**: in shallow waters, light reflected from sandy bottoms, coral reefs, or seagrass beds influences the observed colour, which is why tropical lagoons often appear turquoise.
- **Atmospheric conditions**: cloud cover, aerosols, and atmospheric scattering affect the sunlight reaching the surface; satellite algorithms correct for these effects before estimating ocean colour.

Ocean Colour and Chlorophyll-a

Chlorophyll-a is the principal photosynthetic pigment in phytoplankton and is widely used as an indicator of marine biological productivity. Because it absorbs blue and red wavelengths while reflecting green, satellite sensors can estimate chlorophyll concentration by measuring the colour of the ocean. Higher chlorophyll concentrations generally indicate greater phytoplankton biomass and increased primary productivity, so chlorophyll-a maps from satellites are routinely used to identify productive fishing grounds, monitor algal blooms, and assess ecosystem health.

Marine Productivity

Marine productivity refers to the rate at which marine organisms convert inorganic carbon into organic matter through photosynthesis. This process, known as primary productivity, forms the foundation of marine ecosystems and is carried out mainly by phytoplankton, cyanobacteria, seaweeds, and seagrasses. These organisms capture solar energy and convert carbon dioxide and water into carbohydrates while releasing oxygen. Marine primary productivity supports all higher trophic levels, including zooplankton, fishes, marine mammals, and seabirds.

Types of Marine Productivity

Gross Primary Productivity (GPP) is the total amount of organic matter produced through photosynthesis before any energy is used for respiration. Net Primary Productivity (NPP) is the amount of organic matter remaining after subtracting the energy consumed during

respiration (NPP = GPP − Respiration), and represents the energy available to support consumers within the marine food web.

Factors Influencing Marine Productivity

- **Sunlight** is required for photosynthesis, so productivity is largely restricted to the euphotic zone.
- **Nutrients** such as nitrate, phosphate, and silicate are essential; nutrient-rich regions generally show high productivity.
- **Water temperature** influences growth rates, metabolic activity, and nutrient cycling; extremes reduce productivity.
- **Ocean mixing and upwelling** brings cold, nutrient-rich deep water to the surface, stimulating growth; productive fisheries are commonly associated with upwelling regions.
- **Ocean currents** transport heat and nutrients, shaping the spatial distribution of productivity.
- **Salinity** affects density and stratification, indirectly influencing nutrient mixing and phytoplankton growth.

Distribution of Marine Productivity

Marine productivity is not evenly distributed. Highly productive regions include coastal waters, continental shelves, upwelling zones, polar oceans (during summer), and river mouths and estuaries. Low-productivity regions include central subtropical gyres, stratified tropical oceans, and oligotrophic open-ocean areas. Although the open ocean covers most of Earth's surface, it contributes relatively less primary production per unit area because nutrients are limited.

Ocean Colour Remote Sensing

Satellite remote sensing has transformed the study of ocean colour and productivity. Specialised sensors measure the sunlight reflected from the ocean surface at different wavelengths, and algorithms convert these measurements into estimates of chlorophyll concentration, suspended sediments, and other water-quality parameters. Important missions include SeaWiFS, MODIS (Aqua and Terra), VIIRS, Sentinel-3 OLCI, and the Ocean Colour Monitor (OCM) onboard India's Oceansat satellites. These provide continuous global observations supporting oceanographic research, fisheries management, climate studies, and environmental monitoring.

Applications of Ocean Colour Data

Ocean colour observations are used to monitor phytoplankton distribution, estimate chlorophyll concentration, assess primary productivity, detect harmful algal blooms, identify potential fishing zones, monitor coastal water quality, track sediment plumes and river discharge, study climate change and carbon cycling, and monitor coral-reef and marine-ecosystem health. Satellite-derived ocean-colour data have become indispensable for fisheries agencies, environmental managers, and climate scientists.

Ocean Colour and Climate Change

Climate change influences ocean colour by altering sea-surface temperature, nutrient availability, stratification, and phytoplankton communities. Warming of the upper ocean increases stratification, reducing the upward transport of nutrients; as nutrient availability declines, phytoplankton biomass and chlorophyll concentrations may decrease in many

regions, changing ocean colour and reducing productivity. Conversely, some high-latitude regions may experience temporary increases in productivity due to longer growing seasons and melting sea ice. Continuous satellite monitoring is therefore essential for understanding how marine ecosystems respond to a changing climate.

Ocean Colour, Marine Productivity and Fisheries

Marine productivity forms the basis of all marine fisheries. Areas with high chlorophyll concentrations generally support abundant zooplankton, which feed fish larvae and small pelagic fishes such as sardines and anchovies; these, in turn, sustain larger commercial fishes including tuna and mackerel. Consequently, satellite-derived chlorophyll maps are widely used to identify Potential Fishing Zones (PFZs), helping fishermen improve catch efficiency while reducing fuel consumption and fishing effort.

Marine Food Web

The marine food web is a complex network of feeding relationships among organisms living in oceans and seas. It describes how energy and nutrients are transferred from one organism to another. Unlike a simple food chain, which follows a single pathway, a food web consists of many interconnected food chains because most marine organisms feed on more than one species and are themselves prey for several others. This interconnected nature provides stability and resilience to marine ecosystems, supporting all ocean life from microscopic plankton to the blue whale, and regulating biodiversity, nutrient cycling, carbon storage, fisheries productivity, and overall ecosystem health.

Food Chain and Food Web

A food chain is a simple, linear sequence showing how energy flows from one organism to another, beginning with primary producers and progressing through consumers, for example:

Phytoplankton → Zooplankton → Small Fish → Large Fish → Shark

A food web is a complex network of interconnected food chains that more realistically represents feeding relationships. A single organism may occupy different trophic positions depending on its diet and life stage. A sardine may consume copepods, krill, and fish larvae while serving as prey for tuna, dolphins, seabirds, and sharks. These multiple pathways make ecosystems more resilient: if one prey species becomes scarce, predators can switch to alternatives, so food webs are generally more stable than simple food chains.

Components of the Marine Food Web

Organisms occupy specific trophic levels and can be broadly classified into five groups: producers, primary consumers, secondary consumers, tertiary consumers (including apex predators), and decomposers.

Producers (autotrophs)

Producers form the first trophic level and manufacture their own food through photosynthesis, converting solar energy into chemical energy available to all higher levels. The major marine producers are phytoplankton (cyanobacteria, diatoms, dinoflagellates), seaweeds, kelp, and seagrasses. Among these, phytoplankton are the most important: these microscopic algae drift in the sunlit euphotic zone, are responsible for nearly 50% of the Earth's oxygen

production, absorb vast amounts of atmospheric carbon dioxide, and form the primary food source for zooplankton and many other organisms.

Primary consumers (herbivores)

Primary consumers occupy the second trophic level and feed directly on producers, transferring energy upward. They include zooplankton (rotifers, copepods, cladocerans, salps), krill, small crustaceans, sea urchins, and herbivorous fishes. Zooplankton are particularly important as the vital link between microscopic producers and larger animals, and are the principal food of many larval fishes and small pelagic fishes such as sardines and anchovies.

Secondary consumers

Secondary consumers occupy the third trophic level and feed on herbivores and smaller carnivores like small fishes, squid, jellyfish, crabs, and shrimp. Many commercially valuable fish begin life feeding on zooplankton before shifting to larger prey as they grow, illustrating how an organism's trophic position may vary throughout its life cycle.

Tertiary consumers and apex predators

Tertiary consumers occupy the upper levels and prey on secondary consumers. At the top are the apex predators such as tuna, sharks, dolphins, killer whales, seals, and seabirds — which have few or no natural predators. They maintain ecological balance by regulating prey abundance; their removal through overfishing can trigger trophic cascades and widespread ecological change.

Decomposers

Decomposers, mainly bacteria and fungi, break down dead organisms and organic matter into simpler inorganic nutrients such as nitrogen, phosphorus, and carbon, which become available again for phytoplankton growth. This continuous recycling maintains primary productivity and the long-term sustainability of marine ecosystems.

Trophic Levels

A trophic level is the feeding position occupied by an organism within a food chain or web. Energy flows progressively from lower to higher levels, with each level depending on the one below.

Trophic level	Organisms
First	Primary producers
Second	Primary consumers (herbivores)
Third	Secondary consumers
Fourth	Tertiary consumers
Fifth	Apex predators

Note: *as energy passes through successive levels, only a small proportion becomes available to the next because much is lost through respiration, movement, growth, and metabolism, so higher levels support fewer organisms.*

Biological Pump and the Marine Food Web

The marine food web plays a fundamental role in the biological carbon pump. During photosynthesis, phytoplankton absorb atmospheric carbon dioxide and convert it into organic matter; when these organisms die or are consumed, part of that carbon sinks into deeper waters as marine snow or organic debris, where it can remain stored for centuries or millennia. By removing carbon dioxide from the atmosphere, the biological pump helps reduce greenhouse-gas concentrations and moderates global climate change.

Factors Affecting Marine Food Webs

The structure and productivity of marine food webs are influenced by sunlight, nutrient concentration, water temperature, ocean currents, coastal upwelling, salinity, dissolved oxygen, ocean acidification, climate variability and change, and fishing pressure. Changes in any of these can alter species composition, productivity, and energy transfer.

Human Impacts on Marine Food Webs

- **Overfishing** removes key predators and commercially important species, disrupting predator–prey relationships and causing trophic cascades.
- **Pollution** from plastics, oil spills, pesticides, and heavy metals contaminate habitats, reduce biodiversity, and affect survival and reproduction.
- **Climate change** alters sea temperature, circulation, and species distributions, shifting marine communities.
- **Ocean acidification** reduces the carbonate ions corals, molluscs, and plankton need to build shells and skeletons.
- **Habitat destruction** results in the degradation of coral reefs, mangroves, and seagrass meadows removes critical feeding and nursery habitats.

Importance of Marine Food Webs

Marine food webs transfer energy from producers to consumers, recycle nutrients through decomposition, maintain biodiversity, regulate populations, and support the biological carbon pump. They also sustain global fisheries, contribute to food security for millions, and provide essential ecosystem services that support coastal economies and human well-being.

3. Spotlight Series: Key Phenomena & Case Studies

Climate change is one of the greatest environmental challenges of the 21st century, driven primarily by increasing concentrations of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Oceans play a central role in regulating the Earth's climate by absorbing more than 90% of the excess heat associated with global warming and approximately one-quarter of anthropogenic CO_2 emissions. While this moderates atmospheric warming, it also leads to profound changes in ocean temperature, chemistry, circulation, and sea level, with far-reaching impacts on marine ecosystems, fisheries, biodiversity, and coastal societies.

El Niño and La Niña (ENSO)

The El Niño–Southern Oscillation (ENSO) is the dominant mode of interannual climate variability, resulting from coupled interactions between the tropical Pacific Ocean and the atmosphere. ENSO alternates between the warm phase (El Niño) and the cold phase (La Niña), with each event typically lasting 9–12 months and influencing weather worldwide.

El Niño develops when sea-surface temperatures in the central and eastern equatorial Pacific become significantly warmer than normal due to weakened easterly trade winds and reduced upwelling. This weakens the Walker circulation and shifts tropical convection eastward, so many regions experience reduced monsoon rainfall, droughts, heatwaves, and increased wildfire risk, while others face excessive rainfall and flooding. In the sea, suppressed upwelling reduces nutrients, lowers phytoplankton biomass and productivity, disrupts food webs, triggers coral bleaching, and causes declines in fishery production.

La Niña is the opposite phase, characterised by stronger easterly trade winds and cooler sea-surface temperatures across the central and eastern equatorial Pacific. Enhanced upwelling brings cold, nutrient-rich water to the surface, increasing productivity and fishery yields; it generally strengthens the Indian summer monsoon, bringing above-normal rainfall over South Asia, though intense events can also produce severe floods, landslides, and agricultural losses.

Consequences of ENSO: ENSO modifies rainfall distribution, atmospheric circulation, tropical-cyclone activity, marine heatwaves, droughts, floods, agricultural productivity, freshwater availability, fisheries, and ecosystem functioning, with significant ecological, environmental, and socio-economic implications across tropical and subtropical regions.

Extreme Weather Events

Global warming is increasing both the frequency and intensity of many extreme weather events by adding energy and moisture to the climate system. Rising sea-surface temperatures provide latent heat that fuels tropical cyclones, while a warmer atmosphere holds more water vapour, increasing intense precipitation and flooding. Events like tropical cyclones, marine and terrestrial heatwaves, heavy rainfall, floods, droughts, storm surges, and coastal flooding destroy coastal infrastructure, accelerate erosion, damage coral reefs and mangroves, disrupt fisheries and aquaculture, reduce agricultural productivity, and cause economic losses. Marine heatwaves are especially harmful, triggering coral bleaching, altering species distributions, reducing dissolved oxygen, and increasing harmful algal blooms.

Ocean Acidification

Ocean acidification is the long-term decrease in seawater pH resulting from the absorption of atmospheric carbon dioxide. Dissolved CO_2 reacts with seawater to form carbonic acid, which releases hydrogen ions, reducing pH and decreasing the carbonate ions many organisms need for shell and skeleton formation. This adversely affects calcifying organisms such as corals, molluscs, pteropods, echinoderms, and some plankton by reducing calcification and weakening skeletal structures, and it alters physiology, reproduction, larval development, and species interactions. Combined with ocean warming and deoxygenation, acidification threatens coral-reef ecosystems, shellfish industries, marine fisheries, and the ecosystem services on which millions depend.

Sea (Coastal) Erosion

Coastal erosion is the gradual removal and redistribution of sediments along shorelines by waves, tides, currents, storm surges, and rising sea levels. Climate change accelerates erosion by raising sea level, strengthening wave action, intensifying tropical storms, and increasing extreme coastal events. Consequences include shoreline retreat, loss of beaches, destruction of dunes and wetlands, degradation of mangroves and coral reefs, saltwater intrusion into groundwater and farmland, damage to ports, roads, and infrastructure, and displacement of coastal communities. Low-lying islands and deltaic regions are particularly vulnerable.

Mitigation Against Coastal Erosion

Effective management combines engineered structures with ecosystem-based approaches. Hard engineering methods like seawalls, groynes, breakwaters, revetments, and bulkheads provides immediate protection against wave energy but may alter sediment transport and increase erosion elsewhere. Soft engineering ways like beach nourishment, dune stabilisation, mangrove restoration, salt-marsh conservation, coral-reef rehabilitation, and living shorelines enhances natural resilience while preserving ecosystem functions. Integrated Coastal Zone Management (ICZM), supported by remote sensing, GIS, numerical modelling, hazard mapping, early-warning systems, and sustainable land-use planning, provides a comprehensive framework Integrated Coastal Zone Management (ICZM), for adapting to future coastal risks.

Ecological, Fisheries, and Socio-economic Consequences

Climate change is transforming marine ecosystems by altering species distribution, shifting breeding and migration patterns, disrupting plankton communities, increasing coral bleaching, expanding oxygen-deficient zones, and modifying productivity. These changes propagate through food webs, reducing biodiversity and ecosystem stability. Fisheries are highly sensitive: many commercially important species are shifting toward higher latitudes or deeper waters, altering stock availability, reducing tropical catches, changing spawning seasons, and increasing management uncertainty. Aquaculture is affected through thermal stress, disease, harmful algal blooms, and declining water quality. The socio-economic consequences include reduced food security, declining fishing incomes, infrastructure damage, higher recovery costs, reduced tourism, and displacement of coastal populations with developing countries and small island nations especially vulnerable.

Adaptation and Mitigation Strategies

Addressing climate change requires both adaptation and mitigation. Adaptation reduces vulnerability through ecosystem-based fisheries management, marine protected areas, restoration of mangroves, seagrasses, and coral reefs, climate-resilient aquaculture, improved forecasting, disaster preparedness, and diversification of coastal livelihoods. Mitigation reduces the drivers of climate change by lowering greenhouse-gas emissions through renewable energy and energy efficiency, protecting and restoring blue-carbon ecosystems (mangroves, salt marshes, and seagrasses), promoting sustainable fisheries and aquaculture, and strengthening international cooperation under global climate agreements.

4. Practical Toolkit for the Field

You don't need instruments to make oceanography vivid.The sea already performs it in front of your guests. Match the phenomenon to what's actually visible that day.

Where and When to Look

- **Tides:** check a tide table or app before a backwater or harbour visit. Spring tides (new/full moon) give the most dramatic tidal range; neap tides the calmest water.
- **Upwelling and ocean colour:** point out the day's water colour and catch together. During and after the monsoon, upwelling brings the green, plankton-rich water that fills the nets.
- **Currents and weather:** cyclone season (typically pre- and post-monsoon) and the winter–summer reversal of coastal currents are worth flagging if guests are planning water-based activities.

Reading the Environment

- Muddy or brownish water near a river mouth signals sediment and freshwater discharge, not pollution by default.
- A sudden change in wave height or a receding shoreline before a storm can be a real hazard sign, not just a photo opportunity.
- Unusually warm water or a run of coral bleaching reports locally can be linked back to marine heatwaves and ENSO.

Field Etiquette & Responsible Code of Conduct

- Never take guests into rip currents, surging surf, or a rising tidal bore zone to ‘get closer’ to the phenomenon.
- Respect local warnings and Coast Guard/fisheries advisories on rough seas or cyclone alerts. Reschedule rather than push through.
- Avoid contributing to coastal erosion or dune damage by keeping vehicles and large groups off fragile dune vegetation.

Managing Expectations

Oceanography is mostly invisible. Guests won't see a thermocline or a halocline, and El Niño doesn't look like anything at the beach. Your job is translation: link what they CAN see (water colour, wave size, tide state, a good or bad fish catch) to the larger physical story. Save the more abstract concepts (zonation, trophic levels) for question-driven moments rather than the main narration.

5. Quick-Reference Summary Table

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Tides	Tide table / app reading	Time backwater or shore visits around spring tides for drama, neap tides for calm water.	Spring tides (new/full moon) give the biggest range; neap tides the smallest.
Coastal upwelling	Green, plankton-rich water; active landing centres	Point out the catch and explain the monsoon-driven upwelling behind it.	Monsoon upwelling fertilises the sea: the engine of Kerala's fisheries.
Ocean colour	Blue / green / brown / turquoise water	Use colour differences to talk about phytoplankton, sediment or shallow reflectance.	Ocean colour is a visible proxy for what's living or suspended in the water.
Climate phenomena (ENSO, heatwaves)	Unusual fish landings, coral bleaching reports, erratic monsoon	Link an odd season locally to the wider El Niño / La Niña cycle if guests ask why.	El Niño years often mean weaker upwelling and poorer local catches.

6. Chapter Glossary

- **Zonation:** the division of the ocean into zones by distance from shore, depth, or seafloor character.
- **Neritic zone:** the shallow, highly productive water over the continental shelf, where most commercial fisheries operate.
- **Halocline:** the subsurface layer where salinity changes rapidly with depth.
- **Thermohaline circulation:** the deep, slow global ocean circulation driven by differences in temperature and salinity.
- **Upwelling:** the rise of cool, nutrient-rich deep water to the surface, fuelling productivity along Kerala's coast by the south-west monsoon.
- **Spring / neap tide:** the highest-range tides at new/full moon, and the lowest-range tides at the moon's quarter phases.
- **Tidal bore:** a fast-moving wave that travels upstream into a river or estuary on an incoming tide.
- **Chlorophyll-a:** the main photosynthetic pigment in phytoplankton, used by satellites as a proxy for marine productivity.
- **Trophic level:** an organism's feeding position in a food chain or web either as a producer, consumer, or decomposer.

- **ENSO (El Niño–Southern Oscillation):** the alternating warm (El Niño) and cool (La Niña) phases of Pacific sea-surface temperature that drive global weather and fishery swings.
- **Ocean acidification:** the long-term drop in seawater pH from absorbing atmospheric CO_2, harmful to shell- and skeleton-forming organisms.
- **Marine heatwave:** a prolonged period of unusually warm sea-surface temperature, linked to coral bleaching and shifting species distributions.

7. Sources and Further Reading

- ICAR–Central Marine Fisheries Research Institute (CMFRI), Kochi: oceanographic and fisheries research on the Kerala and Indian coast.
- Indian National Centre for Ocean Information Services (INCOIS): tides, currents, ocean-state forecasts and Potential Fishing Zone advisories for the Indian coast.
- Satellite ocean-colour missions (Oceansat OCM, MODIS, VIIRS, Sentinel-3 OLCI): chlorophyll and productivity monitoring referenced in this chapter.
- Standard physical and biological oceanography references on zonation, tides, currents, waves, salinity and ENSO.

CHAPTER 2

KERALA'S MARINE FISHERIES

An Introduction for Tour Guides

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> **How to Use This Chapter:** *This chapter looks at Kerala through the lens of its marine fisheries, the true heartbeat of a roughly 600-kilometre coastline built on salt, sweat and silver. It covers the people, craft, harbours and heritage behind the catch, the economics and history that shaped the sector, and the governance and challenges it faces today, so a guide can speak to fisheries with the same confidence as backwaters or beaches.*

In This Chapter

1. Introduction & Coastal Context

As tour operators, when you think of Kerala your minds go instantly to the serene backwaters of Alappuzha, the misty tea gardens of Munnar, or our iconic *Kathakali* dancers. Here we are going to look at Kerala through a different lens, a lens of salt, sweat and silver. We are talking about Kerala's marine fisheries, the true heartbeat of our roughly 590-kilometre coastline.

For a tourist, Kerala's coast is a beautiful postcard. But for over a million coastal residents it is a bustling, high-stakes engine of life. Kerala accounts for roughly 13-15% of India's total marine **fish landings**, and more importantly for your business. It shapes the very identity of the destination you are selling.

Every time your guests enjoy a plate of spicy *Karimeen Pollichathu* or a fiery fish curry, they are tasting the bounty of a unique marine ecosystem driven by the Arabian Sea upwelling. Every time they photograph the massive Chinese fishing nets in Fort Kochi, or watch hundreds of traditional wooden boats piercing the heavy surf at dawn, they are witnessing a living museum of ancient and modern maritime heritage.

Understanding our fisheries is your secret weapon for crafting unforgettable itineraries. From the historic Indo-Norwegian Project roots in Neendakara (Kollam) that changed Indian fisheries history, to the incredible local phenomenon of Chakara (the seasonal mud-banks) where the sea literally throws fish to the shore, the stories here are deeply captivating for travelers.

As the travel industry shifts toward authentic, immersive and sustainable experiences, Kerala's fishing culture offers an untapped goldmine. We will break down how this marine world operates from the types of traditional and mechanised vessels to our bustling harbours and exactly how you can package this coastal heritage into unique, responsible 'Blue Tourism' experiences for your global clients.

Marine Fisheries of Kerala: The Basics

1. Marine Fisheries of Kerala

Kerala, on the south-west coast of India, is one of the nation's most productive and vibrant maritime states. It accounts for roughly 13–15% of India's total marine fish landings. The state's fisheries sector serves as a massive socio-economic engine, supporting the livelihoods of over one million coastal residents and contributing significantly to national export earnings.

Geographical Advantages & Ecology

Kerala's dominance in marine fishing stems from its unique geographic and oceanographic features.

- **The coastline:** spans about 590 km officially re-estimated at 600.15 km in 2024 across nine coastal districts, with Thiruvananthapuram, Kollam, Ernakulam and Kozhikode being especially intensive fishing zones.
- **The Arabian Sea upwelling:** during the south-west monsoon, nutrient-rich deep waters rise to the surface along the Kerala coast. This triggers massive plankton blooms that fuel huge populations of pelagic fishes such as Oil Sardine (Mathi) and Indian Mackerel (Ayala).
- **A broad continental shelf:** Kerala has a wide continental shelf of nearly 40,000 square kilometres rich in bottom-dwelling (demersal) species like prawns, cuttlefish and soles set within an expansive Exclusive Economic Zone (EEZ).

The Multi-Tier Fleet Structure

The state's fishing economy operates through a carefully balanced, multi-tier system that blends ancestral heritage with mechanical scaling.

- **The traditional sector** uses small dugout canoes and catamarans in the immediate surf zone, preserving age-old community techniques.
- **The motorised sector:** this is the true backbone of local markets, which consists of traditional hulls fitted with high-power outboard motors (OBMs) to rapidly deploy massive ring-seine nets (Thanguvala) for daily coastal catches.
- **The mechanised sector** witnesses large, multi-day stern trawlers, purse-seiners and longliners that fish deep offshore waters for days at a time, feeding the state's lucrative seafood-export industry.

Institutional Framework & Socio-Economics

Fisheries in Kerala are tightly woven into the socio-cultural fabric of coastal communities, governed and supported by specialised state institutions.

- **Governance:** the Kerala Department of Fisheries, under the State Fisheries Minister, regulates conservation laws, enforces the seasonal monsoon trawl ban, and manages welfare infrastructure.
- **Cooperative network (Matsyafed):** the Kerala State Co-operative Federation for Fisheries Development eliminates exploitative middlemen by managing fish auctions, distributing subsidised fuel, and offering micro-credit to traditional fishers.
- **Research hubs:** Kochi serves as the scientific capital for Indian fisheries, hosting top-tier institutes such as the Central Marine Fisheries Research Institute (CMFRI) and the Central Institute of Fisheries Technology (CIFT).

Economic Dynamics of Kerala's Marine Fisheries

The marine fisheries sector is a vital component of Kerala's economy, contributing roughly 1.6% to the Gross State Domestic Product (GSDP) and nearly 10% to the Gross State Value Added (GSVA) within the primary sector. Driven by surging export values and steady domestic consumption, it generates multi-crore revenues annually.

1. Global Trade & Export Revenues

Kerala is a leading gateway for Indian seafood exports, sending high-value marine products to markets across the European Union, USA, Japan and Southeast Asia.

- **Financial output:** the state generates over ₹5,000 crore annually in seafood-export revenues, commanding roughly a 13–14% share of India's total marine-export value.

High-value species: while pelagic fish dominate local landing volumes, the export economy relies heavily on premium demersal catches like cephalopods (squid and cuttlefish processed out of hubs like Cochin), crustaceans (coastal prawns and deep-sea shrimp), and finfish (yellowfin tuna, reef cod and ribbonfish).

2. Domestic Valuation & Consumption

Unlike many states where fish is purely an export commodity, Kerala possesses an exceptionally strong domestic market.

- **Per-capita consumption:** a consumer in Kerala eats on the order of 20-25 kg of fish per year (some CMFRI estimates put it near 30 kg), roughly three to four times the national Indian average of about 9 kg. Kerala is among the highest fish-consuming states in the country.

- **High price realisation:** CMFRI notes that even when catch volumes stabilise, the economic valuation of landings continues to break records, driven by exceptional consumer demand and strong price realisation at both landing centres and retail markets.

3. Socio-Economic Catchment & Safety Nets

The commercial gains from the sea are balanced against a massive human infrastructure that prevents economic displacement.

- **Employment multiplier:** the industry sustains over 800,000 fisherfolk directly in capture fishing, marketing, processing and ancillary boat-building services across 222 coastal villages.
- **The Matsyafed micro-economy:** the Kerala State Co-operative Federation for Fisheries Development (Matsyafed) helps stabilise the coastal economy. It cuts out exploitative middlemen through standardised beach-level auctions, runs thrift groups, and returns the maximum share of the 'consumer's rupee' directly to the primary fishermen.

Historical Evolution: Four Epochs

Kerala's marine fisheries are best understood through a handful of pivotal moments and systems, the historical turning points that built today's fleet, the gear and craft themselves, the harbours that anchor the trade, and the law that now governs it.

3. Historical Evolution of Kerala's Marine Fisheries

The history of marine fisheries in Kerala is a journey from localised, community-managed subsistence fishing to a highly commercialised, technology-driven export industry. It can be traced across four distinct epochs.

1. The Pre-Modern Era (before 1953): the subsistence base

For centuries, Kerala's marine fishing was entirely beach-bound and deeply integrated into the local social order.

- **Ecological adaptation:** fisherfolk relied on indigenous knowledge of ocean currents and the seasonal Arabian Sea upwelling (Chakara).
- **Craft & gear:** fishing used non-motorised craft such as logs lashed into catamarans in the south and dugout canoes (Thoni) in the north with passive nets of cotton or coir.
- **Economics:** the catch was sold or bartered locally within a small radius, for lack of modern ice-preservation technology.

2. The Mechanisation Phase (1953–1979): the Blue Revolution

The defining turning point in India's marine history came with the Indo-Norwegian Project (INP) in 1953.

- **The Neendakara experiment:** launched at Neendakara (Kollam), the INP which was Norway's first foreign-aid venture introduced the first mechanised boats with diesel engines, modern nylon nets and ice factories, shifting operations from beach landings to harbour-based fishing.
- **The shrimp rush:** from the late 1960s, booming global demand for frozen shrimp ('pink gold') transformed the sector. Merchants from outside the traditional fishing community entered the market, building large stern trawlers to sweep the seabed for export-ready prawns.

3. Conflict and Motorisation (1980–1999): social realignment

The rapid, unguided rise of mechanised bottom-trawling damaged the coastal seabed, depleted fish stocks and marginalised traditional fishers left with barren near-shore waters.

- **Fishworker uprisings:** the 1980s saw historic social movements led by artisanal fishworkers demanding safety zones. This forced the government to enact the Kerala Marine Fishing Regulation Act (KMFRA) of 1980, which restricted mechanised trawling near the coast and established the seasonal monsoon trawl ban.
- **The OBM revolution:** to compete with fast trawlers, traditional fishers motorised their country craft, fitting detachable outboard motors (OBMs) onto large plank canoes paving the way for the ring seine (Thanguvala), which reclaimed dominance over the pelagic market.

4. The Modern Regulatory Era (2000–present): the sustainability pivot

Entering the 21st century, the focus shifted from maximising catch volumes to preventing resource collapse.

- **Tech-driven tracking:** modern boats now use satellite navigation, ISRO's NavIC alert system, and Distress Alert Transmitters (DATs).
- **Policy focus:** the Kerala Department of Fisheries enforces Minimum Legal Size (MLS) rules to curb juvenile catches, while national schemes such as PMMSY offer subsidies to move crowded fleets away from near-shore waters into deep-sea tuna longlining.

Crafts and Gears

Major Fishing Gears of Kerala

Marine fishing gears in Kerala fall broadly into traditional (artisanal), motorised and mechanised types, each targeting specific ecological niches from the surface to the deep ocean floor.

1. Pelagic gears (surface & column feeders)

These target highly mobile, schooling fishes near the surface, such as Oil Sardine and Indian Mackerel.

- **Ring seines (Thanguvala):** the most dominant gear in Kerala's motorised sector is the ring seines operated from large plank-built boats with outboard motors, encircling entire fish schools rapidly.
- **Purse seines:** large, heavily mechanised commercial nets used by bigger vessels; they surround a school and draw a 'purse line' to close the bottom like a drawstring bag.

2. Mid-water & passive gears

These rely on fish movement or baiting rather than active chasing, making them highly selective.

- **Gillnets (Ozhukkuvala / Kambavala):** vertical walls of netting hung in the water column; fish are caught by the gills as they try to swim through. Mesh sizes are regulated to target species such as seer fish, tuna or mackerel.
- **Hook and line (Choonda):** used in both traditional and multi-day mechanised sectors, with baited hooks targeting high-value predators like tuna, barracuda and groupers along reefs and in deep water.

3. Demersal gears (bottom dwellers)

These operate on or near the seabed for prawns, cuttlefish, squid and flatfishes.

- **Bottom trawls:** funnel-shaped nets towed along the sea floor by mechanised trawlers, held open by heavy 'otter boards'. Highly productive but strictly regulated because of their impact on the seabed.
- **Shore seines (Kambavala / Karamadi):** a traditional beach-landing net in which one end stays on shore while a boat casts the net in a semicircle close to the beach, and the whole net is then hauled ashore by teams of fishers.

Marine Fishing Crafts / Vessels of Kerala

The fleet is legally and operationally categorised into three sectors: mechanised, motorised (artisanal) and traditional (non-motorised).

Mechanised sector (deep-sea & multi-day)

Large, stable vessels of steel or marine-grade fibreglass (FRP), with heavy inboard engines, mechanical winches, wheelhouses and insulated fish holds packed with ice for long voyages.

- **Stern trawlers:** the most dominant mechanised type; they tow funnel-shaped bottom nets and operate for 7 to 15 days at sea, targeting premium demersal species like prawns, cuttlefish and squid.
- **Multi-day gillnetters & longliners:** built for selective high-end fishing, travelling far into deep oceanic waters to deploy miles of gillnets or baited longlines for large pelagics such as tuna, billfish and sharks.

Motorised sector (the artisanal backbone)

This sector bridges traditional roots with modern speed, using traditional hull designs built or modified in fibreglass and powered by detachable outboard motors (OBMs) of 9.9 to 40 HP.

- **Ring-seine canoes (Thangu Vallam):** massive, flexible plank-built or FRP canoes up to 25 m long, operating in pairs or trios with high-power OBMs to deploy ring-seine nets for sardines and mackerel; they return to shore the same day.
- **Plywood and FRP canoes:** smaller, agile vessels crewed by 2 to 4 fishers, using small OBMs to run gillnets or hook-and-line gear close to the coast.

Traditional sector (non-motorised artisanal)

This shrinking sector relies entirely on muscle, wind and ancestral knowledge, uses no fossil fuel, and operates within a few kilometres of the beach.

- **Dugout canoes (Thoni):** carved from a single large tree trunk (historically mango or anjili wood), propelled by paddles to reach near-shore schools.
- **Catamarans (Kattumaram):** simple rafts of lightweight logs lashed together; common in southern Kerala (the Thiruvananthapuram coast), they are highly resilient to heavy surf breaking on the beach.

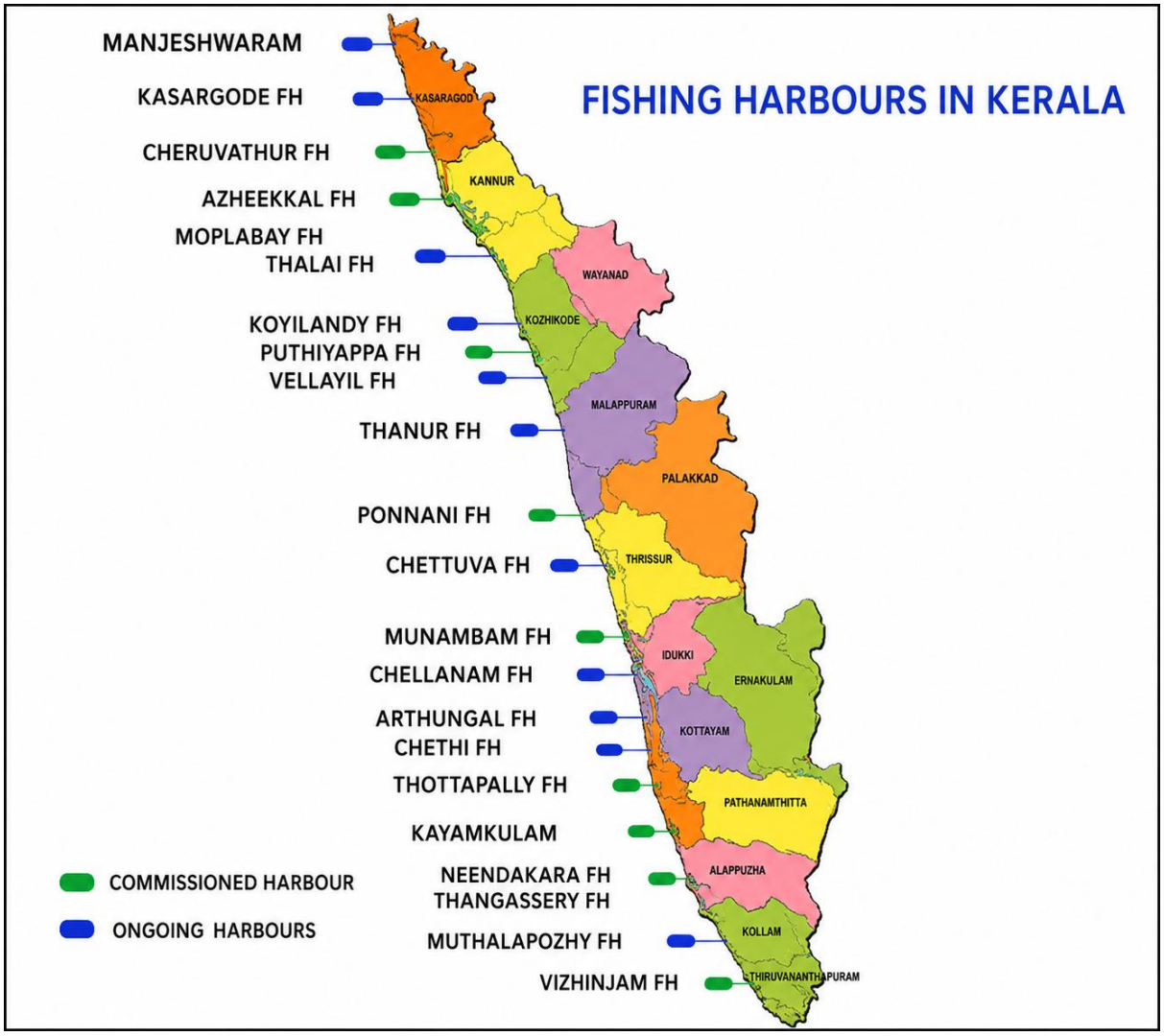
Fleet Comparison Matrix

Vessel class	Typical length	Propulsion	Crew	Operational range	Major ports in Kerala
Mechanised trawler	15 – 25+ m	100 – 500 HP inboard	8 – 15	Deep sea (EEZ)	Munambam, Sakthikulangara, Vizhinjam
Motorised canoe	8 – 15 m	9.9 – 40 HP outboard	3 – 6	Territorial waters (<12 nm)	Kalamukku, Chellanam, Chombala
Ring-seine vessel	20 – 25 m	Multiple OBMs (up to ~120 HP total)	25 – 40	Coastal waters (<20 nm)	Arthunkal, Thottappally, Beypore
Traditional boat	5 – 9 m	Oars / canvas sails	1 – 3	Near-shore surf zone	Beach-landing sites

Vessel Registration & Safety

The Kerala Department of Fisheries enforces mandatory vessel management through the national ReALCraft (Registration and Licensing of Fishing Craft) portal.

- **Colour coding:** Kerala fishing vessels carry specific hull and wheelhouse colours, making it easy to tell registered local boats from foreign or interstate vessels.
- **Distress monitoring:** all mechanised and large motorised vessels must install Distress Alert Transmitters (DATs) or NavIC satellite receivers for real-time weather alerts and emergency tracking.



Fishing Harbours of Kerala

Kerala has an extensive network of maritime infrastructure along its ~590 km coastline, managed primarily by the Harbour Engineering Department. The state operates around 20 fishing harbours alongside about 128 smaller Fish Landing Centres (FLCs**)** to support its marine economy.

Major harbours

- **Cochin (Thoppumpady) and Munambam:** the two major commercial harbours, both in Ernakulam district. They cater primarily to the deep-sea, multi-day mechanised fleet, with extensive breakwaters, deep berths, large auction halls and fuel stations, handling export

catches like yellowfin tuna, squid and cuttlefish. Cochin Fisheries Harbour is currently undergoing a ₹169-crore modernisation.

- **Neendakara & Sakthikulangara:** this twin setup in Kollam forms the largest fishing-harbour complex in Kerala, and is the traditional epicentre of the state's shrimp-trawling industry.
- **Vizhinjam Fishing Harbour:** in Thiruvananthapuram, a naturally deep harbour serving both traditional longliners and mechanised boats, right beside the newly developed Vizhinjam International Seaport.

Infrastructure Layout: Inside a Kerala Harbour

Standardised harbour layouts are engineered for quick turnaround and catch freshness.

- **Breakwaters** are giant stone-walled barriers extending into the sea to create a calm basin, letting boats berth safely even during heavy monsoon swells.
- **Wharf & auction halls** are concrete platforms where boats dock to unload; the fish are sorted into crates and moved to step-like auction halls.
- **Ice plants & cold storage** are high-capacity flake-ice facilities in or beside the harbour to chill the fish immediately for local transport or export processing.
- **Bunkering points** are dedicated fuel-dispensing stations providing subsidised diesel or kerosene directly to the vessels.

Governance and Structural Changes: The KMFRA

The Kerala Marine Fishing Regulation Act (KMFRA) of 1980 and its later amendments transformed how the state's marine economy is managed, shifting Kerala from an unregulated 'free-for-all' into a strictly zoned, biologically managed maritime territory. The landmark changes rest on four pillars.

1. Spatial zoning (the conflict fix)

To stop aggressive mechanised vessels from destroying near-shore fishing grounds and to prevent violent mid-sea clashes the KMFRA split the sea into legally enforced zones.

- **Exclusive artisanal zone:** mechanised trawlers and purse-seiners were barred from fishing within the first 10 kilometres (roughly 5.4 nautical miles) of the coast, reserved for traditional and motorised country craft.
- **Mechanised zone:** deep-sea vessels were pushed beyond the 10 km line into territorial waters and the EEZ to minimise ecosystem damage.

2. The seasonal monsoon trawl ban

One of the most radical environmental interventions in global tropical fisheries was a **seasonal ban on bottom trawling** during the south-west monsoon.

- **The measure:** trawling is halted for 52 days (typically from early/mid-June to the end of July).
- **The impact:** this gives the seabed an annual resting period during the peak spawning season of key demersal species like prawns and threadfin breams, allowing stressed stocks to replenish.

3. Net mesh-size restructuring

To stop operators using fine-mesh 'mosquito nets' that scooped up everything blindly, the KMFRA introduced firm gear standards.

- **Trawl cod-end limit:** the minimum legal mesh size for a trawler's cod-end (the tail of the net where fish collect) was set at 35 mm.
- **Juvenile escape:** this mesh lets small, juvenile fish and baby prawns slip through, ensuring they live long enough to reproduce at least once.

4. The modern pivot: Minimum Legal Size & facility registration

As overfishing escalated in the 21st century, driven partly by demand from interstate fishmeal factories, the state passed major updates through the KMFRA Amendment Acts of 2017 and 2021.

- **The MLS mandate:** for the first time in India, Kerala legally defined a Minimum Legal Size (MLS) for 58 commercially vital species (e.g., Oil Sardine at 10 cm, Indian Mackerel at 15 cm). Landing, transporting or selling catches below these sizes invites heavy penalties and vessel impoundment.
- **Upstream regulation:** the law reached past the water's edge, giving the state the right to inspect and register boat-building yards and net-production factories on land choking the supply of illegal vessels and unapproved nets before they ever reach the sea.
- **Fisheries Management Councils:** the reforms institutionalised decentralised councils at three levels, giving artisanal fishermen a direct, democratic seat alongside scientists and officials to shape zoning rules.

Core Challenges & Future Outlook

While highly productive, Kerala's marine fisheries sector faces shifting modern pressures.

- **Climate & safety:** increasing frequency of extreme weather events (such as cyclones) and coastal erosion complicate traditional beach landing.
- **Juvenile depletion:** intense commercial competition has led to overfishing of localised stocks, prompting strict Minimum Legal Size (MLS) enforcement.

- **The deep-sea pivot:** under initiatives like the Pradhan Mantri Matsya Sampada Yojana (PMMSY), the state is actively moving fishers from overcrowded coastal waters into sustainable offshore deep-sea tuna longlining.

> *As is obvious, some of the information above needs to be updated every year. You can easily do so using online sources or by contacting ICAR–CMFRI. Let me wish you all success, not only as a responsible tour guide but also as an ambassador of the heritage and the sustainable existence of our fisherfolk, whose life is still a gamble with the perilous sea.*

4. Practical Toolkit for the Field

Understanding fisheries turns a passing glance at a harbour into a genuine story by using the cues below to read what's happening in front of your guests.

Where and When to Look

- **Harbours:** visit early morning for the auction and the freshest catch; Cochin (Thoppumpady), Munambam, Neendakara–Sakthikulangara and Vizhinjam are the most visitor-accessible major harbours.
- **The monsoon trawl ban:** this 52-day pause (roughly early/mid-June to end of July) means fewer mechanised boats but a good moment to explain why the ban exists and to focus on traditional/motorised craft instead.
- **Chakara:** look for the seasonal mud-bank phenomenon in a handful of stretches, where the sea calms dramatically and fish gather close to shore which is a striking, purely local story to tell if it's the season.

Reading the Environment

- Hull colour coding and registration marks distinguish local registered boats from others is a quick, visual talking point at any harbour.
- The craft itself tells the story: a dugout canoe or catamaran signals the traditional sector; a plank canoe with an outboard motor and ring-seine gear is the motorised backbone; a large steel or FRP vessel with a wheelhouse is the mechanised, multi-day fleet.
- A busy ice plant and full auction hall indicate a good landing day while a quiet harbour may simply mean the boats are still at sea.

Field Etiquette & Responsible Code of Conduct

- Keep groups out of the working area of an auction or unloading wharf.
- Ask before photographing individual fishers or their catch up close.
- Do not encourage guests to buy undersized (below Minimum Legal Size) fish, even if offered. It undermines the very regulations that keep stocks healthy.
- Respect harbour safety rules. Wet, busy wharves with moving winches and boats are a real hazard, not a viewing gallery.

Managing Expectations

A harbour visit is at its best early morning around an auction. Outside that window, or during the monsoon trawl ban, expect a quieter scene with fewer boats and less visible activity.

Frame this honestly rather than promising a bustling market every time. The Chakara mud-bank phenomenon and large offshore catches are seasonal and site-specific, not guaranteed sights on any given day.

5. Quick-Reference Summary Table

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Harbours & landing centres	Oil sardine, Indian mackerel, prawns, tuna	Visit early morning for the auction; note hull colour-coding and craft type.	Kerala lands roughly 13–15% of India's total marine fish catch.
Traditional & motorised craft	Dugout canoe, catamaran, ring-seine canoe (Thangu Vallam)	Identify the sector by the craft and gear, not just the catch.	The ring seine (Thanguvala) is the dominant motorised-sector gear today.
Mechanised fleet	Stern trawlers, gillnetters, longliners	Explain the monsoon trawl ban if visiting June–July.	A 52-day trawl ban each monsoon lets the seabed and stocks recover.
Governance (KMFRA)	Zoning, Minimum Legal Size, mesh-size rules	Use MLS rules to explain why very small fish shouldn't be bought or sold.	The KMFRA (1980) was one of the first laws in India to zone the sea by vessel type.

6. Chapter Glossary

- **Thanguvala (ring seine):** the dominant motorised-sector gear in Kerala, encircling schools of sardine and mackerel.
- **Chakara:** a local, seasonal mud-bank phenomenon where calm water and abundant fish gather close to shore.
- **KMFRA:** the Kerala Marine Fishing Regulation Act (1980), which zones the sea by vessel type and sets the monsoon trawl ban.
- **MLS (Minimum Legal Size):** the smallest size at which a given species may legally be landed, transported or sold.
- **EEZ (Exclusive Economic Zone):** the zone extending from a country's coast within which it has special rights over marine resources.
- **OBM:** outboard motor is the detachable engine that motorised much of Kerala's traditional fishing fleet.
- **Matsyafed:** the Kerala State Co-operative Federation for Fisheries Development, supporting fishers through auctions, credit and subsidies.

- **Demersal / pelagic:** living on or near the seabed / living in the open water column is a basic split in fisheries targeting.

7. Sources and Further Reading

- ICAR–Central Marine Fisheries Research Institute (CMFRI), Kochi - marine fisheries resource assessments and the Marine Fisheries Census.
- Kerala Department of Fisheries - the Kerala Marine Fishing Regulation Act (KMFRA) and its amendments, harbour and vessel registration data.
- Central Institute of Fisheries Technology (CIFT), Kochi - craft, gear and fishing-technology research.
- Matsyafed (Kerala State Co-operative Federation for Fisheries Development) - marketing and socio-economic data.

Note: landing figures, export values and fleet counts move year to year — refresh from the latest CMFRI / Department of Fisheries data before a briefing.

CHAPTER 3

MARINE LIFE OF KERALA

A Tapestry of the Open Sea, Estuaries, Backwaters and Beaches

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How to Use This Chapter: *Behind Kerala's famous backwaters lies a whole living continuum, the open Lakshadweep Sea, mangrove-fringed estuaries, brackish backwaters and dynamic beaches, each with its own creatures, from plankton and sardines to karimeen, prawns, clams, ghost crabs and nesting turtles. This chapter moves habitat by habitat, so a guide can read any stretch of Kerala's coast and tell its story. Use the Spotlight Series to build a handful of memorable species stories for your talk, and the Practical Toolkit to know where, when and how to show them responsibly.*

In This Chapter

1. Introduction & Coastal Context

Kerala, the narrow strip of land between the Western Ghats and the Lakshadweep Sea on India's south-west coast, is celebrated for its monsoon landscapes, rivers and backwaters. Yet one of its richest natural inheritances lies in a realm less immediately visible than its hill stations or paddy fields: its marine and coastal life. With a coastline of nearly 600 km, numerous estuaries and lagoons, a dense network of rivers descending rapidly from the Ghats to the sea, and productive nearshore waters influenced by monsoon-driven upwelling, Kerala supports a striking mosaic of aquatic ecosystems. These include the open Lakshadweep Sea, brackish estuaries fringed in places by mangroves, the backwaters and inland lagoons, and the sandy beaches and surf zones that form the state's shifting edge with the ocean. Each of these habitats sustains distinct communities, from microscopic plankton to sharks, sardines, prawns, dolphins, sea turtles and migratory shorebirds.

Marine life in Kerala is not simply an ecological asset; it is deeply interwoven with the economy, food culture, folklore and social history of the state. Sardine and mackerel fisheries have shaped livelihoods and cuisine; prawn and clam fisheries have sustained estuarine communities; and boat-building traditions, fish-landing centres, seafood markets and coir villages all reflect a long relationship between people and water. The south-west monsoon, the upwelling of nutrient-rich waters along the coast and the seasonal flushing of rivers into estuaries together create one of the most productive marine belts in India. At the same time, Kerala's coastal biodiversity is under growing pressure from overfishing, habitat loss, pollution, sand mining, coastal erosion, invasive species, climate change and unplanned development.

To understand Kerala's marine life, it is best to move through habitats like the the open sea, estuaries and mangroves, backwaters, and beaches, as this chapter does. Rivers feed estuaries, estuaries merge into backwaters, backwaters nurture fisheries, beaches host the return of nesting turtles, and the open sea receives and redistributes the biological wealth of them all. Together these habitats form a connected coastal continuum, and the thread running through this chapter and through Kerala's identity as a coastal state is exactly that: connection.

2. Core Concepts & Environmental Dynamics

The Open Sea: Kerala and the Lakshadweep Sea

The open sea off Kerala forms part of the Lakshadweep Sea, one of the most productive marine regions of the Indian Ocean. Unlike enclosed lagoons or estuaries, it is a vast pelagic and demersal realm shaped by oceanic currents, monsoon winds, coastal upwelling, freshwater discharge and seasonal stratification. During the south-west monsoon, strong winds drive the upwelling of deeper, cooler, nutrient-rich water along the coast, fertilising the upper layers of the sea and supporting rich fisheries, especially of oil sardine, Indian mackerel, anchovies, seerfish and tuna.

Ecologically, the open sea can be read in broad zones. Closest to shore lies the neritic zone over the continental shelf, where sunlight penetrates the upper waters and most commercial fisheries operate; farther offshore, the oceanic zone supports tunas, billfishes, sharks and migratory cetaceans; and the seafloor itself hosts prawns, crabs, molluscs and benthic fish.

At the base of the food web are phytoplankton, grazed by zooplankton, which in turn feed small pelagic fish which are the crucial middle link that converts plankton productivity into prey for tunas, sharks, dolphins and seabirds. Though invisible to most beachgoers, this plankton-driven engine governs fishery yields, and any shift in it from warming, stratification or nutrient imbalance propagates upward to commercially important stocks.

Reefs and the Deep Sea

Although Kerala's mainland coast is a soft-bottom coast, coral-reef fishes are associated with the fringing and patch-reef habitats reported at Vizhinjam (Thiruvananthapuram) and Thikkodi (Kozhikode) where butterflyfishes, angelfishes, parrotfishes, groupers and snappers are distributed. Beyond the shelf and down the upper continental slope lies the deep-sea fauna like deep-sea sharks, lanternfishes, hatchetfishes and dragonfishes, in cold, dark, high-pressure water, many showing striking adaptations such as bioluminescent organs and reduced skeletons.

Estuaries and Mangroves: Where Rivers Meet the Sea

If the open sea is Kerala's great marine expanse, the estuaries are its zones of negotiation between land and ocean. Here river water and seawater mix, sediments settle, nutrients accumulate and salinity shifts with tide and season; in places mangroves line the creek margins and muddy shores, creating sheltered habitats of exceptional ecological value.

Estuaries are defined by fluctuating salinity: during the monsoon, heavy river discharge freshens the upper reaches, while in the dry season tidal ingress pushes saline water farther inland. Only euryhaline species, those tolerant of a wide salinity range, dominate estuarine food webs. Because many commercially important marine prawns and fish use Kerala's estuaries as nurseries, damage to these habitats directly affects offshore fisheries. Productivity here is driven not only by phytoplankton but also by detritus from mangroves and marsh vegetation, broken down by microbes and detritivores, feeding worms, molluscs, juvenile fish and prawns, and drawing in egrets, herons, cormorants and migratory waders.

Backwaters: Kerala's Brackish Arteries of Life

Kerala's backwaters are among the most distinctive coastal landscapes in India: long, shallow, interconnected lagoons and canals running parallel to the sea and linked to estuaries, river mouths and tidal inlets. Neither fully marine nor fully freshwater, Vembanad, Ashtamudi, Kayamkulam and related systems are biological arteries sustaining fisheries, shellfisheries, aquaculture, water transport, tourism and long-settled human communities.

The backwaters are shaped by monsoon runoff, tides, river inflow, bunds, barrage operations, sedimentation and land use. In places like Kuttanad where paddy cultivation below sea level has led to major hydrological interventions such as the Thanneermukkom barrage, which alters salinity and ecological rhythms. Even so, the backwaters remain among Kerala's richest aquatic ecosystems, their shallow waters supporting phytoplankton, macrophytes, zooplankton, prawns, crabs, clams, fishes and waterbirds. These are places where Kerala's freshwater and marine worlds overlap most visibly.

Beaches: The Dynamic Edge of Land and Sea

Kerala's beaches are often celebrated for sunsets, fishing villages and tourism, but ecologically they are among the most dynamic habitats in the state. These are shifting environment shaped by waves, tides, currents, wind and seasonal erosion–accretion cycles. Organisms here must cope with instability, salt spray, drying, pounding surf and moving sand, producing a specialised community of burrowers, scavengers, filter feeders, shorebirds and occasional nesting reptiles.

Beaches divide into broad zones. The dry upper beach or berm, the moist mid-shore, the swash zone, and the shallow surf zone just offshore, each with characteristic inhabitants. Ghost crabs dominate the upper and mid-beach at night; mole crabs and surf clams inhabit the swash zone; polychaete worms and small crustaceans live beneath the sand; and sea turtles may crawl ashore to nest. Organic matter washed ashore feeds scavengers and enriches the sandy ecosystem, while shorebirds probe the wet sand for worms and crustaceans.

3. Spotlight Series: Flagship Species & Case Studies

Open Sea Spotlights

Indian Oil Sardine *Sardinella longiceps*

- **Ecological Narrative:** No fish is more emblematic of Kerala's marine identity. For generations it has been a staple food, a pillar of coastal livelihoods and a species whose annual abundance is discussed almost like the weather. Oil sardines form immense shoals in the upper layers of the sea and feed mainly on plankton; they are fast-growing, short-lived and highly responsive to monsoon-driven productivity, classic forage fish, abundant enough to transfer plankton-derived energy up to larger predators.
- **Conservation Status & Threats:** Not currently assessed as threatened, but landings fluctuate significantly with oceanographic conditions and fishing pressure, making the sardine a closely watched indicator of the health of Kerala's fisheries.

Indian Squid *Uroteuthis duvaucelii*

- **Ecological Narrative:** Squids are cephalopods rather than fish, intelligent, fast-growing predators equipped with large eyes, grasping arms and jet propulsion. The Indian squid is widely fished and highly valued as seafood; it feeds on small fish, prawns and other cephalopods, and in turn is eaten by tunas, dolphins and larger predatory fish. Squids are masters of rapid colour change thanks to specialised skin cells called chromatophores, used for both camouflage and communication.
- **Conservation Status & Threats:** Short-lived and fast-growing, cephalopod populations are generally resilient to fishing pressure; the Indian squid is not a species of particular conservation concern, but remains subject to standard fishery management as a commercially important stock.

Whale Shark *Rhincodon typus*

- **Ecological Narrative:** Although not a common coastal sighting, the whale shark occasionally enters the narrative of Kerala's open sea as a symbol of oceanic wonder. Despite its enormous size, it is a harmless filter feeder, straining plankton and small

organisms from the water, and represents both the grandeur of offshore biodiversity and the importance of conserving migratory megafauna.
- **Conservation Status & Threats:** Listed as Endangered by the IUCN globally, and legally protected in India under Schedule I of the Wildlife (Protection) Act, 1972. Principal threats across its range are targeted hunting, bycatch and vessel strikes.

Also sharing the open sea, the wider cast your guests will meet at any landing centre:

- Indian Mackerel (Rastrelliger kanagurta) is a sleek, schooling plankton-feeder among the most valuable small pelagics of the south-west coast.
- Anchovies & whitebaits (family Engraulidae) are fundamental to the food web, converting plankton into edible biomass at speed.
- Seerfishes (Scomberomorus commerson & others) are fast, muscular predators among the most prized fish landed on the coast.
- Tunas (skipjack & yellowfin) are highly mobile open-ocean predators that keep their muscles warmer than the surrounding sea.
- Ribbonfishes (Trichiurus lepturus) are long, silver, blade-like predators important in trawl and gillnet fisheries.
- Cuttlefishes (Sepia spp.) are close relatives of squid, prized as an export seafood, carrying an internal cuttlebone for buoyancy.
- Jellyfishes (various) are ancient drifters whose blooms may signal shifts in currents, temperature or predator numbers.

Estuary & Mangrove Spotlights

Pearlspot (Karimeen) *Etroplus suratensis*

- **Ecological Narrative:** The pearlspot, known locally as karimeen, is perhaps the most iconic fish of Kerala's brackish waters. It inhabits brackish lagoons, estuaries and backwaters, tolerates substantial salinity variation, and is a substrate-spawning cichlid whose parents guard the eggs and protect the fry which is a fine example of parental care among Kerala's estuarine fishes. Its biogeography is equally remarkable: *Etroplus* is native to peninsular India and Sri Lanka, yet its closest living relatives are the Malagasy cichlids of Madagascar, a connection thought to reflect an ancient Gondwanan lineage separated when the Indian plate drifted away from Madagascar tens of millions of years ago.
- **Conservation Status & Threats:** Not currently threatened; abundant and increasingly farmed in brackish-water aquaculture, though wild populations depend on healthy estuarine nursery habitat and water quality.

Also sharing the estuary are the wider community around the karimeen:

- Giant Tiger Prawn (Penaeus monodon), one of the most economically important estuarine crustaceans, dependent on estuarine nurseries before moving to deeper marine habitats.
- Indian White Prawn (Fenneropenaeus indicus) is common in brackish waters and highly important to fisheries and aquaculture.
- Kaadal / poovalan prawn (Metapenaeus dobsoni) is a mainstay of the state's shrimp fishery, underpinning traditional tide-fed 'chemmeen padam' shrimp fields.

- Mud crabs (Scylla spp.) are large, commercially valuable crabs of muddy burrows and mangrove-lined shallows.
- Fiddler crabs (Uca & allied genera) are small mudflat crabs where males wave one enlarged claw to attract females; few creatures better capture the character of a tropical estuary.
- Grey mullets (family Mugilidae) are hardy, schooling, often detritivorous fishes that graze microalgae and organic film.
- Asian Seabass / Barramundi (Lates calcarifer), a euryhaline ambush predator, biologically notable for protandry (beginning life as male, later becoming female).

Estuarine oysters and clams are equally important, though often overlooked. By filtering water they remove suspended particles and contribute to nutrient cycling and water clarity, while their shells create microhabitats for algae, worms and small crustaceans.

Backwater Spotlight

Karimeen (pearlspot) deserves special emphasis here too, since it is the quintessential fish of Kerala's brackish lagoons to the backwaters what the sardine is to the open sea. Its full profile appears above under the Estuary & Mangrove spotlights. The backwaters' own signature species, though, is a much smaller, quieter animal that has built an entire industry around itself:

Black Clam *Villorita cyprinoides*

- **Ecological Narrative:** The black clam is one of the defining benthic organisms of Kerala's backwaters, especially in systems such as Vembanad and Ashtamudi. It lives partly buried in soft sediment and feeds by filtering suspended particles from the water. Dense clam beds also stabilise the sediment and provide surfaces and crevices for algae, worms, juvenile crabs and other invertebrates, an entire small economy and habitat built on one unassuming clam.
- **Conservation Status & Threats:** Clam fisheries have long provided livelihoods, and Kerala's shell-lime industry historically depended on shell resources from such bivalves; harvest pressure and habitat change are recognised concerns for sustaining clam beds over the long term.

Also sharing the backwaters:

- Green mussel (Perna viridis), one of Kerala's best-known shellfish, increasingly important to mariculture, filtering suspended particles from the water.
- Giant freshwater prawn (Macrobrachium rosenbergii) is the impressive long-blue-clawed prawn of inland and low-salinity waters, central to Kerala's food economy.
- Mud crabs (Scylla spp.) are major benthic predators and scavengers, supporting both capture fisheries and fattening operations.
- Mullets, catfishes & gobies (various) fill the middle of the backwater food web, grazing algae, detritus and organic-rich sediment.

Although birds are not marine organisms in the strict taxonomic sense, they are integral to the ecology of Kerala's backwaters. Cormorants, darters, egrets, herons, terns, gulls and migratory ducks use these waters for feeding and roosting. (They have their own chapter in this manual.)

Beach Spotlights

Olive Ridley Turtle *Lepidochelys olivacea*

- **Ecological Narrative:** The olive ridley is the sea turtle most commonly associated with Indian coasts, and it occurs in Kerala's marine waters and nests on some beaches. It feeds on crustaceans, molluscs, jellyfish and other invertebrates, and females return to sandy beaches to lay eggs above the high-tide line. Its embryos show temperature-dependent sex determination, with warmer sands producing more females. Its most famous behaviour globally is the arribada, or synchronised mass nesting, seen spectacularly on parts of India's east coast though Kerala does not host arribadas of that scale.
- **Conservation Status & Threats:** Listed as Vulnerable by the IUCN and protected under Schedule I of India's Wildlife (Protection) Act, 1972. Temperature-dependent sex determination makes nesting populations vulnerable to climate warming, alongside threats from nest disturbance, beach lighting, plastic pollution and incidental capture in fishing gear.

Ghost Crab *Ocypode spp.*

- **Ecological Narrative:** Ghost crabs are perhaps the most conspicuous beach animals if you visit at dawn or dusk. Fast, pale and mostly nocturnal, they dig burrows deep into the sand and emerge to scavenge, hunt and patrol the shoreline. Their tracks often decorate the morning beach as delicate records of night-time activity.
- **Conservation Status & Threats:** Not individually assessed, but widely used as a simple bioindicator of beach health: heavily disturbed or artificially lit beaches support far fewer ghost crabs, an easy and memorable thing for a guide to point out.

Also sharing the beach and surf zone:

- Green turtle (Chelonia mydas), larger than the olive ridley, is primarily herbivorous as adults; its nesting fidelity to natal beaches is one of the most remarkable phenomena in marine biology.
- Sand bubblers (Dotilla & allied crabs) are small crabs that feed on organic films on sand grains, leaving tell-tale pellet trails around their burrows.
- Surf clams & wedge shells (Donax spp.) are specialised swash-zone filter feeders that burrow in a flash to avoid being washed away.
- Rocky-shore & tide-pool life (various) include seaweeds, limpets, isopods, nudibranchs and sea urchins specialised for life between the tides.

A pocket guide to marine gastropods is provided to participants as a ready reckoner to the common shells found on the beach.

4. Practical Toolkit for the Field

The gift of this chapter is that every stretch of coast has a story. Match what you show to the habitat in front of you, and you can turn any beach walk or backwater cruise into a window on one of India's most intricate living systems.

Where and When to Look

- **At a harbour or the open shore:** the sardine and mackerel shoals in the day's catch, squid, cuttlefish, ribbonfish and seerfish.
- **At estuaries and mangroves:** karimeen, prawns and mud crabs, and the fiddler crabs waving on the mudflats at low tide.
- **On the backwaters:** clam beds, mussel racks, karimeen among the weed, and gatherings of waterbirds.
- **On the beach:** timing is everything. Come at dawn or dusk and at low tide for ghost crabs and their tracks, shorebirds probing the wet sand, sand-bubbler pellets and swash-zone clams; explore rocky-stretch tide pools separately.

Reading the Environment

- Tell the upwelling story of why the monsoon sea turns green and rich with fish. It explains the sardine and mackerel catch in one sentence.
- Explain that estuarine and mangrove creeks are nurseries.
- Frame the backwaters as a brackish world tuned by tide, monsoon and the Thanneermukkom barrage, neither fresh nor marine.
- Use ghost crab activity as a simple beach-health signal: plenty of crabs and tracks means a healthy, lightly disturbed beach.

Field Etiquette & Responsible Code of Conduct

- Never collect live shells or animals. Identify with the pocket shell guide and leave them where they are.
- Never disturb turtle nests or nesting females.
- Keep nesting beaches dark and quiet.
- Carry out all litter.

> **Conservation Note:** *Olive ridley turtles are Schedule I protected species. Approaching a nesting female, shining lights toward her, or handling eggs or hatchlings is both ecologically harmful and illegal. Keep guests at a respectful distance and quiet at all times.*

Managing Expectations

Sardines, mackerel, squid, karimeen, clams and crabs are the reliable daily baseline. Guests will see these on almost any visit to a harbour, estuary, backwater or beach. Whale sharks and dolphins are rare, memorable bonus sightings, not guarantees. Turtle nesting is seasonal and site-specific, and Kerala does not host mass arribadas on the scale of India's east coast, so set expectations accordingly. A single nesting female or a fresh crawl-track is still a genuine privilege to see. For the birds, and for the whales, dolphins and otters, point guests onward to this manual's Birds and Marine Mammals chapters.

5. Quick-Reference Summary Table

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Open sea (Lakshadweep Sea)	Oil sardine, Indian mackerel, whale shark	Point out the day's catch and explain the upwelling story.	Monsoon upwelling fertilises the sea: the engine of Kerala's fisheries.
Estuaries & mangroves	Karimeen, tiger prawn, mud crab	Look for karimeen, prawns and mud crabs, and fiddler crabs on the mudflats at low tide.	Estuaries are nurseries. Harm here is felt out at sea.
Backwaters	Black clam, green mussel, karimeen	Show clam beds, mussel racks and waterbird gatherings.	Neither fresh nor marine- a brackish world tuned by tide and monsoon.
Beaches & surf zone	Olive ridley turtle, ghost crab	Visit at dawn or dusk and low tide for crabs, shorebirds and tide pools.	A 'bare' beach is alive- ghost crabs signal its health.

6. Chapter Glossary

- **Pelagic / demersal / benthic:** living in the open water column / near the seabed / on or in the seabed.
- **Neritic & oceanic zones:** the shallow, productive water over the continental shelf, and the deep water beyond it.
- **Upwelling:** the rise of cool, nutrient-rich deep water to the surface, here driven by the south-west monsoon that fuels productivity.
- **Plankton (phyto- / zoo-):** drifting microscopic plants and the tiny animals that graze them.
- **Forage fish:** small, abundant plankton-feeders (sardines, anchovies) that pass energy up to larger predators.
- **Euryhaline:** able to tolerate a wide range of salinity.
- **Estuary / brackish water:** where river meets sea, and the mix of fresh and salt water found there.
- **Detritus:** decaying plant and animal matter that feeds estuarine and backwater food webs.
- **Nursery ground:** a sheltered habitat where juvenile fish and prawns grow before moving to the sea.
- **Filter feeder:** an animal (clam, mussel, whale shark) that strains food particles from the water.
- **Chromatophores:** pigment cells that let squids and cuttlefishes change colour for camouflage and signalling.

- **Protandry:** beginning life as a male and later becoming female, as in the Asian seabass.
- **Temperature-dependent sex determination:** the nest temperature setting the sex of turtle hatchlings: warmer sand, more females.
- **Arribada:** the synchronised mass nesting of ridley turtles (famous on India's east coast).
- **Ecosystem engineer:** a species that reshapes its habitat like burrowing crabs aerating the mud or clams filtering the water.

7. Sources and Further Reading

- ICAR–Central Marine Fisheries Research Institute (CMFRI), Kochi - research and publications on the marine biodiversity, fisheries and oceanography of the Kerala coast.(http://eprints.cmfri.org.in)
- CMFRI marine fishery resource assessments for the oil sardine, Indian mackerel, prawns, clams and other landings of Kerala.
- The pocket guide to marine gastropods provided to participants - a ready reckoner to the common shells of the beach.
- Standard references on Indian marine fishes, crustaceans, molluscs and sea turtles, and on the biogeography of the etropline cichlids (the India–Madagascar connection).

Note: species names and conservation status change with new research; refresh a fact if a guest queries it.

CHAPTER 4

MARINE MAMMALS OF KERALA'S COAST AND SEAS

A Field-Oriented Lecture Note for Tour Guides

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> **How to Use This Chapter:** *This chapter introduces marine mammals as groups of cetaceans, sirenians, pinnipeds and otters and explains the biology that makes them remarkable, then dwells on the charismatic species you can actually show along the Kerala coast, each with a memorable hook. It includes a practical field toolkit for responsible whale- and dolphin-watching and for handling strandings, a quick-reference table, a glossary and sources.*

In This Chapter

1. Introduction & Coastal Context

A marine mammal is a mammal that has adapted to life in the sea, breathing air, warm-blooded, giving birth to live young and feeding them on milk, yet at home in salt water and often near the top of the marine food web. Some are purely oceanic; others come close to shore into lagoons and estuaries. Worldwide there are around 130 species of marine mammals with about 90 of them are cetaceans (whales, dolphins and porpoises), and Indian waters harbour roughly 30 species, almost all of them cetaceans, together with the dugong.

Kerala's coast, nearly 600 kilometres along the south-eastern Arabian Sea, is one of the most productive marine stretches in India. Its mosaic of sandy beaches, rocky shores, estuaries, backwaters, mangroves, mudflats and continental shelf, fed by the south-west monsoon, west-flowing rivers and coastal upwelling, supports a rich base of plankton, fish and squid. For marine mammals these productive waters offer foraging grounds, migratory corridors and, in places, nursery areas. Dolphins are the animals your guests are most likely to see close to shore; whales are usually further out; and otters work the rivers, estuaries and coastal wetlands where fresh water meets the sea.

A guide's calendar and where to look

Most sightings are opportunistic, but there are patterns. Dolphins gather year-round at productive estuaries and bar-mouths, (Kochi, Azhikode, Munambam and Kollam among them), where tidal mixing concentrates fish. Whales are creatures of deeper, offshore water, most likely on boat trips beyond the shelf, and are more active around the monsoon's productive pulses. Otters are seen in family parties in the backwaters and river mouths, often early and late in the day. Be honest with guests: these are wild animals, never guaranteed, the search itself is part of the pleasure.

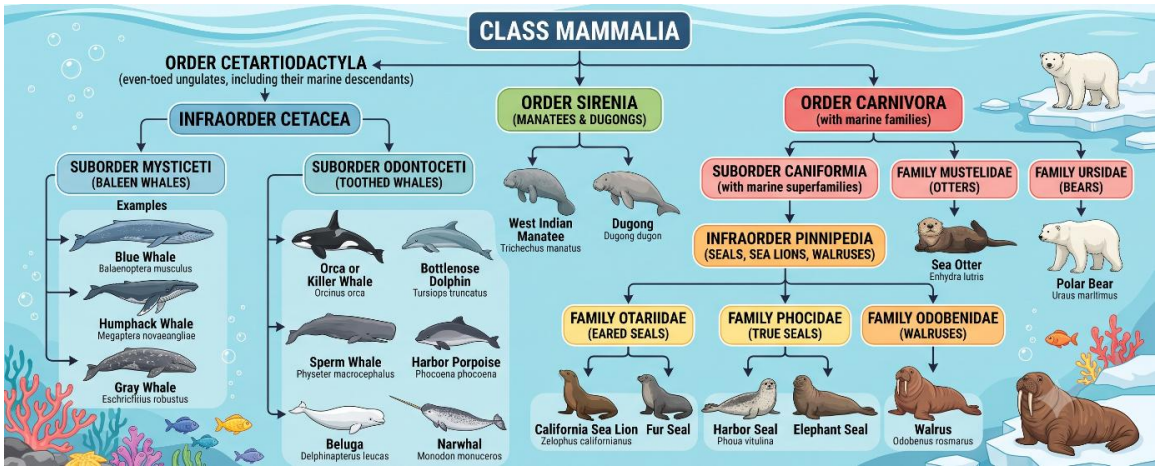
2. Core Concepts & Environmental Dynamics

The Four Groups of Marine Mammals

To most people 'marine mammal' means whales and dolphins, but the diversity is far greater. By evolutionary history, living marine mammals fall into four groups.

- **Cetaceans** *(whales, dolphins & porpoises)* are the largest and most fully aquatic group, with streamlined bodies and highly specialised breathing and sensory systems; these are the marine mammals your guests will meet in Kerala.
- **Sirenians** *(dugongs & manatees)* are the only plant-eating marine mammals; the dugong is India's sole 'sea cow', grazing seagrass meadows, but it is found in the Gulf of Mannar, Palk Bay and the Andaman & Nicobar Islands — not along the Kerala coast.
- **Pinnipeds** *(seals, sea lions & walruses)* are part-land, part-sea animals that come ashore or onto ice to rest and breed; a major group worldwide, but not found naturally in Indian waters.
- **Marine fissipeds** *(sea otters & polar bears)* are 'land-footed' marine mammals of other regions; India's own otters are river-and-estuary members of the weasel family (Mustelidae), not true marine mammals, but they are treated here for the coastal habitats they share.

Though they come from different evolutionary lineages, these animals often play similar ecological roles, sitting high in marine food webs, shaping the abundance of their prey, and serving as barometers of ocean health.



Whales, Dolphins and Porpoises: Telling Them Apart

All whales, dolphins and porpoises belong to the cetaceans, but there are useful distinctions your guests will enjoy. The first great divide is by feeding apparatus.

Baleen whales vs toothed whales

Baleen whales have no functional teeth. Instead, hundreds of flexible keratin plates or *baleen* hang from the upper jaw and act as a natural sieve: the whale takes in a huge gulp of water full of plankton or small fish, then pushes the water out through the baleen and swallows the trapped prey. This lets the very largest animals feed on some of the smallest, which is how the blue whale can be the largest animal ever to live. Toothed whales keep teeth for life and pursue individual prey; the group includes sperm whales, beaked whales, killer whales, and all the dolphins and porpoises, most of which use echolocation, the biological sonar, to find fish and squid in dark or murky water.

Dolphins vs porpoises

Dolphins are, in fact, small toothed whales, and not a separate group. They tend to have a longer, sleeker body, often a distinct beak, a curved (falcate) dorsal fin, and highly social habits, living in groups called pods. Porpoises are easily confused with them but differ in the details: a shorter, rounder head with little or no beak, spade-shaped rather than conical teeth, often a small triangular fin, and shyer habits. They surface briefly and tend to avoid boats. The one porpoise recorded in Indian coastal waters, the Indo-Pacific finless porpoise, is unusual in having no dorsal fin at all.

From Land to Sea: Evolution and Adaptation

Marine mammals live in the sea but are not fish: they breathe air with lungs, are warm-blooded, bear live young and nurse them on milk, all features that place them firmly in the class Mammalia alongside elephants, deer and humans. Their fish-like shape is a case of convergent evolution, where unrelated groups arrive at similar solutions to the same challenge.

The move from land to sea is one of the most astonishing stories in the history of life. The ancestors of today's whales were not ocean giants but small, four-legged land mammals living along riverbanks and coastal floodplains around 50 million years ago, in the Eocene. Early forms such as *Pakicetus* still bore their weight on land, but details of the skull and ear already hint at a growing life in water. Over millions of years the hind legs shrank until the pelvis was reduced to tiny remnants buried in the body; the forelimbs became flippers; and the tail evolved into powerful horizontal flukes for thrust.

One of the clearest changes was the migration of the nostrils from the tip of the snout to the top of the head, forming the blowhole. So the animal can breathe with barely a break in the surface. Dense fur, useful for warmth on land but a drag in water, gave way in most species to blubber, a thick fat layer that insulates, stores energy and adds buoyancy. Yet the past still shows through: whales carry vestigial pelvic bones, and a flipper opened up reveals the same humerus, radius, ulna and finger bones as any mammal's arm where evolution reworking an old design rather than inventing a new one.

Other marine mammals took other roads. Seals and their kin descend from land carnivores but still return to land or ice to breed. India's dugongs are the last plant-eating marine mammals, sharing a distant ancestry with elephants. And smooth-coated otters keep a foot in both worlds, resting and rearing young along riverbanks, mangroves and coastal wetlands. Different lineages, one lesson: the remarkable power of life to adapt.

How Marine Mammals Feed

Food at sea is patchy. Currents, monsoons, river discharge and undersea topography concentrate plankton, fish and squid in particular places, and marine mammals have evolved very different ways to exploit it.

Baleen whales- filter feeding

Blue, fin and Bryde's whales take the smallest prey in vast quantities: krill, copepods or small schooling fish. Rather than chasing individuals, the whale lunges into a dense patch with its mouth agape, taking in more water than its own body, then uses its tongue to force the water out through the baleen, trapping the prey inside. It is proof that microscopic food, in high enough density, can sustain the largest animals on Earth.

Dolphins - active hunting

Dolphins hunt individual prey with speed, agility and sharp senses, taking small pelagic fish such as sardines, anchovies, mackerel, scads, and squid, and using echolocation to find them in murky estuaries or at night. Many hunt cooperatively, herding fish into tight balls or driving them against sandbars, with pod members taking turns, which is a display of communication and teamwork. Along the Kerala coast, humpback dolphins are seen regularly at bar-mouths and estuaries, where the meeting of fresh and salt water fuels the fisheries that feed both dolphins and people.

Sperm whales - deep-sea predators

Some toothed whales occupy an entirely different niche. Sperm whales dive to hunt squid in the ocean's twilight and midnight zones, dives that can exceed one kilometers in depth and last over an hour, a feat of extraordinary physiology.

Dugongs - grazing

Unlike the cetaceans, the dugong is a vegetarian, grazing almost exclusively on shallow seagrass meadows. Using its muscular, down-turned muzzle it uproots seagrass, leaving winding feeding trails across the seabed; like grazing on land, this can encourage fresher, more nutritious growth. Healthy seagrass is therefore essential to this threatened species, one more reason these habitats matter.

Otters - apex predators of rivers and estuaries

Smooth-coated otters work the rivers, backwaters, mangroves and estuaries, taking fish, crabs, prawns, molluscs and the occasional amphibian. Superb swimmers, they use sensitive whiskers

to detect the tiny movements of hidden prey and dexterous forepaws to handle it and sometimes crushing shells against rocks before eating, a rare bit of tool use among marine mammals.

Feeding as an ecological process

These meals do more than feed an animal. By controlling prey, transporting nutrients and moving energy between habitats, marine mammals help keep whole ecosystems in balance: dolphins reshaping fish schools in estuaries, whales lifting nutrients through the water column, dugongs tending seagrass, otters regulating estuarine fish and crustaceans. Each meal sustains an individual and, through it, the wider system.

Family Life: Breeding, Calves, Learning and Society

A marine mammal's survival depends not only on finding food but on raising the next generation. Unlike fish that spawn thousands of eggs and leave, marine mammals invest heavily in a few well-cared-for young, giving them protection and years of learning, because a newborn must quickly master breathing, swimming, finding food and avoiding danger in a demanding world.

Breeding and birth

Breeding varies with ecology and migration. Many large whales feed at high latitudes in summer, then migrate to warm tropical or subtropical waters in winter to mate and calve, where thin-blubbered newborns are safer. Courtship can involve vocal signals, close swimming and male competition; humpback whales famously sing elaborate songs in the breeding season, thought to attract mates and signal to rival males. Dolphins breed less strictly by season, often timing calves to peaks of food, with courtship of synchronised swimming, body-rubbing, chasing and calls.

Gestation is long, from about ten months to over a year, so the young are well developed at birth. Almost always there is a single calf; twins are very rare and hard to raise. Whales, dolphins and dugongs give birth in water, usually tail-first, which keeps the head in the birth canal until the last moment and reduces the risk of drowning; the mother then nudges the newborn to the surface for its first breath. Otters, by contrast, den along riverbanks or in vegetation, and pups enter the water only gradually with the mother.

Lactation

Milk is the signature of mammals, and at sea it is extraordinary. Marine-mammal milk is exceptionally rich in fat- sometimes 30–50% in some whales - letting calves lay down insulating blubber fast. Nursing underwater is a challenge: the mother pumps milk into the calf's mouth with muscles around the mammary glands, while the calf curls its tongue around the nipple to seal out sea water. Growth is rapid by which some baleen-whale calves gain tens of kilograms a day, among the fastest of any mammal. Calves later sample solid food while still nursing, and the social bond with the mother often outlasts weaning by years.

Learning from experience

Much marine-mammal behaviour is learned, not merely instinctive. Young dolphins shadow their mothers, learning where to find prey, how to echolocate, how to avoid predators and how to read a complex coast. A celebrated example is 'sponging' in which some bottlenose dolphins in Shark Bay, Australia, carry marine sponges on their beaks to protect them while foraging on the seabed, a skill passed from mother to calf rather than inherited genetically. It has not been seen in Indian dolphins, but it makes the key point: marine mammals are not born knowing everything; vital skills come from watching, doing and interacting. Young otters likewise learn to hunt by following adults, clumsy at first and steadily more skilled.

Social lives and communication

Marine mammals include some of the most socially complex animals outside the primates. Most dolphins live in pods of a few to several hundred, in a flexible fission-fusion system where individuals come and go. Small groups forages efficiently, while large groups are offering safety and society. Within pods they cooperate: hunting together, guarding against predators, aiding the injured and protecting the young. Sperm whales live in stable families of related females and calves; killer whales in long-term matrilineal pods led by older females; smooth-coated otters in family units that share territory defence, grooming and foraging.

Because light fades fast underwater but sound carries far, cetaceans live largely by sound. Dolphins use whistles, clicks and burst-pulsed calls: whistles to stay in contact, click-trains to echolocate. Strikingly, each bottlenose dolphin develops its own 'signature whistle' early in life, gaining a sort of acoustic 'name' that lets pod members recognise and call one another. The low, booming calls of great whales can travel hundreds of kilometres in the right conditions which is vital for animals scattered across the open ocean. This dependence on sound is also why underwater noise from ships and industry is so damaging, and why separating calves from mothers, or losing experienced adults, can erase knowledge a whole population relies on.

Ecosystem Engineers: The Whale Pump and the Whale Fall

For years whales were seen only as huge consumers of ocean life. Recent science tells a richer story: whales help keep the ocean productive.

The whale pump

Great whales feed at depth on fish and krill, then return to the surface to breathe and rest where they release nutrient-rich faeces. These nutrients (nitrogen, phosphorus and especially iron) act as natural fertiliser for phytoplankton, the microscopic plants that form the base of nearly all marine food chains and that, in turn, produce much of the world's oxygen and absorb large amounts of carbon dioxide. By carrying nutrients up from the depths, the whale pump boosts productivity across wide areas; and on their long migrations whales also move nutrients horizontally, from rich high-latitude feeding grounds to nutrient-poor tropical seas.

The whale fall

A second wonder follows a whale's death. When a great carcass sinks, it becomes a whale fall which is a concentrated feast that can sustain a specialised deep-sea community of sharks, fish, crustaceans, worms and bacteria for years or even decades in the food-poor abyss. Together these discoveries have overturned the old view: whales are not merely consumers but major players in nutrient cycling, carbon storage and ocean productivity. Conserving whales, it turns out, means conserving the ecosystems they help to run.

Why Dolphins Gather at Kerala's Estuaries

Dolphins appear so reliably at river mouths like Kochi and Azhikode because estuaries are extraordinarily productive. Where nutrient-laden fresh water meets nutrient-rich seawater, microscopic phytoplankton bloom, and with them the fish. Dolphins do not need the estuary itself; they come for the dense fish these productive waters hold. Tidal currents help by concentrating fish into predictable places, and dolphins exploit these natural aggregations, sometimes working together to push fish against sandbars and shallows where they are easier to catch. The very same sites are vital to local fisheries, a neat illustration that a healthy estuary serves wildlife and community alike.

Strandings: What They Are, and How to Respond

Even the most capable marine mammals strand along underwater noise from shipping and coastal works that can disrupt an animal's health or coasts from time to time. A live stranding is when a whale, dolphin or other marine mammal comes ashore or into shallow water and cannot get itself back out, sometimes one animal, sometimes a group. Strandings rarely have a single cause. Natural ones include disease, old age, predation, difficult births, severe weather, navigational error and shifting oceanographic conditions; a sick or injured animal that can no longer swim properly may simply come ashore. Increasingly, human causes are involved too: entanglement in fishing gear, ship strikes, swallowed plastic, pollution, and navigation. Every stranded animal - alive or dead - is also a chance to learn about the species and the pressures on the sea.

Responding to a stranding: what a guide should do

Citizens and guides are often first on the scene, and the first hours matter. The guidance is simple and firm:

- **Alert the authorities first.** Call the Forest Department, Fisheries Department, Coast Guard or a trained marine-wildlife rescue group before doing anything else.
- **Do not push the animal back out to sea** unless a trained responder directs it. Animals often strand because they are seriously ill or injured, and refloating them can make things worse.
- **Keep people and noise back.** Hold the crowd at a distance to reduce the animal's stress.
- **Never let water into the blowhole.** Marine mammals breathe air, not water; keep the blowhole clear. If appropriate, trained responders may gently pour seawater over the body to keep it cool and moist, avoiding the blowhole.
- **Help data reach the experts.** Trained staff photograph, measure and sample the animal which are records that inform distribution, health, disease and conservation. In India, stranded animals have yielded new distribution records and key population insights.
- **Report dead animals too.** A dead stranding still needs the authorities, for post-mortem and safe disposal or burial.

Responsible Whale and Dolphin Watching ('Blue Tourism')

Whale- and dolphin-watching is among the fastest-growing forms of nature tourism worldwide. Done well, it lets visitors enjoy marine life in the wild, builds support for conservation and provides livelihoods for coastal communities, and it shows animals' natural behaviour far better than any captive display. On the Kerala coast, dolphins are seen near the bar-mouths and estuaries of Munambam, Azhikode, Kollam and Kochi, ecological transition zones where river and sea mix to feed abundant fish. Local operators and fishers often hold generations of traditional ecological knowledge about seasonal dolphin movements.

But done badly, watching harms the very animals it celebrates. Because dolphins depend on sound to feed, navigate and communicate, boat noise and crowding can disrupt feeding, resting and nursing, forcing animals to spend energy evading vessels. Approaching too closely can separate mothers from calves and alter travel routes; fast boats risk collisions, especially with calves that surface often; and persistent disturbance has been linked, in heavily visited places, to reduced use of habitat and even lower breeding success. Small disturbances repeated over years add up.

Principles of responsible watching

The golden rule is simple: observe without disturbing.

- **Approach slowly and predictably.** No sudden changes of speed or direction; let the animals set the terms.

- **Keep your distance.** Maintain enough space that the animals' behaviour does not change. Never chase, never try to cut an individual out of the group, never surround a pod with boats or block the path of moving animals.
- **Take extra care around calves.** Young animals surface more often and depend entirely on their mothers; disturbance here can disrupt nursing and rest.
- **Cut the noise.** Reduce engine noise as far as possible, and limit time spent with any group.
- **Never feed or touch wild dolphins.** It changes natural behaviour, breeds dependence on people and risks injury from boats and gear.

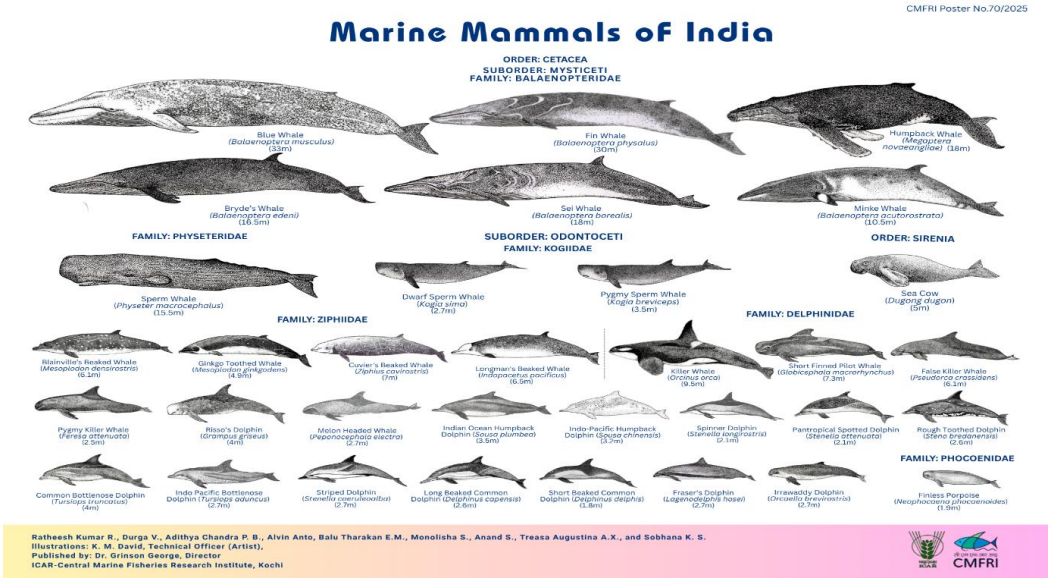
Threats and the Road Ahead

Marine mammals evolved over millions of years in seas that were essentially free of people. In just the last two centuries, rapid coastal development and marine activity have brought new dangers. The main threats are entanglement in fishing gear (especially gillnets), vessel strikes from fast and commercial boats, habitat loss through reclamation and pollution, plastic and abandoned 'ghost' gear, underwater noise from shipping, dredging and seismic surveys, and the long-term effects of climate change on ocean temperature, productivity and prey.

Because many marine mammals breed slowly, often a single calf every few years. Populations recover only slowly once hit, so conservation must protect whole ecosystems, not just individual animals. The good news is that better research, stronger laws, and rising public awareness and community involvement have driven real gains worldwide. Kerala's coast remains a stronghold for several dolphin species, its offshore waters a highway for migratory whales, and its wetlands a refuge for otters. Protecting estuaries, curbing pollution, promoting sustainable fisheries and encouraging responsible wildlife tourism will keep them part of Kerala's living heritage — and every fisher's sighting, every recorded stranding, every child who thrills to a first dolphin is part of that effort.

Marine Mammals and the Law

Marine mammals are among the most strongly protected wildlife in India and worldwide. In India, all cetaceans are protected under the Wild Life (Protection) Act, 1972, which bans their hunting, capture, possession and trade; the dugong receives the Act's highest level of protection. The Act also provides the legal basis for rescue, research, habitat protection and prosecution of offences. The Forest Departments, working with the Fisheries Department, Coast Guard, research institutions and local bodies, carry out this protection on the ground.



Because marine mammals ignore political borders, India also supports international agreements. CITES controls trade in endangered species; the Convention on Migratory Species (CMS) fosters cooperation for species that cross national boundaries, as many Indian Ocean whales and dolphins do; and the International Whaling Commission (IWC**)** supports whale science and conservation worldwide. India has never engaged in commercial whaling, and its role in these programmes helps protect the migratory whales that pass through its waters.

Science and Citizens in Conservation

Laws alone cannot conserve marine mammals; sound science on their distribution, numbers, trends, behaviour and threats is essential. Researchers use several non-invasive methods:

- **Visual surveys** from boats along set routes, recording sightings, group size, behaviour and conditions to estimate abundance and distribution.
- **Photo-identification,** recognising individuals by natural marks on fins, flukes or scars, to track survival, movements, breeding and social ties over time.
- **Passive acoustic monitoring,** listening for calls with underwater microphones (hydrophones) — invaluable where animals are more often heard than seen.
- **Drones, DNA and satellite tags,** to assess body condition with minimal disturbance, identify species from stranded or degraded material, and reveal migrations spanning whole ocean basins.

Just as important are citizens. Fishers are often the first to see dolphins, whales or a drifting carcass, and their reports of sightings, movements and unusual events are genuinely valuable. Prompt reporting of a stranding lets responders help the animal and lets scientists learn from it. Cutting plastic, disposing of fishing gear responsibly and supporting sustainable fisheries all make for healthier seas, and educators who inspire young people build the stewardship on which the future depends. Successful conservation, in the end, rests on a shared understanding that healthy oceans serve wildlife and people alike.

3. Spotlight Series: Flagship Species & Case Studies

The Marine Mammals of Kerala

7. The marine mammals of Kerala

The marine mammals recorded off Kerala are almost all cetaceans, and dolphins are by far the most frequently seen, by fishers, researchers and coastal people. Most other species live largely underwater, surfacing only to breathe and often far offshore, so much of what we know comes from dedicated surveys, fishers' observations and stranded animals. Here are the ones a guide is most likely to talk about.

Indian Ocean Humpback Dolphin *Sousa plumbea*

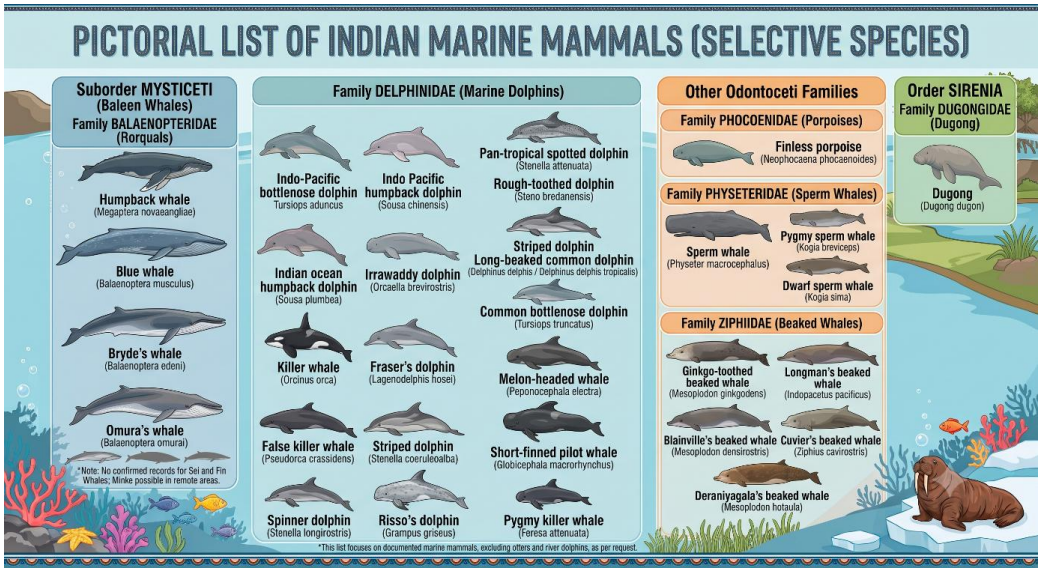
- **Ecological Narrative:** The signature coastal dolphin of the Kerala shoreline. It favours shallow inshore water and is closely tied to bays, estuaries and river mouths, rarely venturing far offshore. Adults are identified by their large bodies, long beak and the distinctive hump at the base of the dorsal fin that gives the species its name. Unlike wide-ranging oceanic dolphins, humpback dolphins show high site fidelity, staying within small home ranges for long periods which, together with their love of productive coastal water, makes them highly vulnerable to coastal development, fishing and vessel traffic.
- **Conservation Status & Threats:** Listed as Endangered, it is a flagship for the health of Kerala's estuaries.

Indo-Pacific Finless Porpoise *Neophocaena phocaenoides*

- **Ecological Narrative:** The only porpoise in Kerala's waters, and easy to overlook. With no dorsal fin and no beak, it presents a plain, low profile when it surfaces, spends little time visible, and tends to shy away from boats. It prefers shallow inshore waters and estuaries, the same places where fishing is concentrated, which puts it at real risk of accidental capture in nets.
- **Conservation Status & Threats:** Listed as Vulnerable.

Bryde's Whale *Balaenoptera edeni*

- **Ecological Narrative:** The baleen whale most often seen off Kerala, and the one your offshore guests have the best chance of encountering. Unlike whales that migrate between polar feeding grounds and tropical breeding grounds, Bryde's whales stay in warm tropical and subtropical waters all year, lingering in productive upwelling zones of the Arabian Sea and feeding mainly on schooling fish such as sardines, anchovies and mackerel. Usually solitary or in small groups, they surface quietly with a low, hooked fin and can be surprisingly hard to spot on a calm sea.
- **Conservation Status & Threats:** Listed as Least Concern globally, though poorly known in our waters which is why fishers' and guides' records genuinely matter.



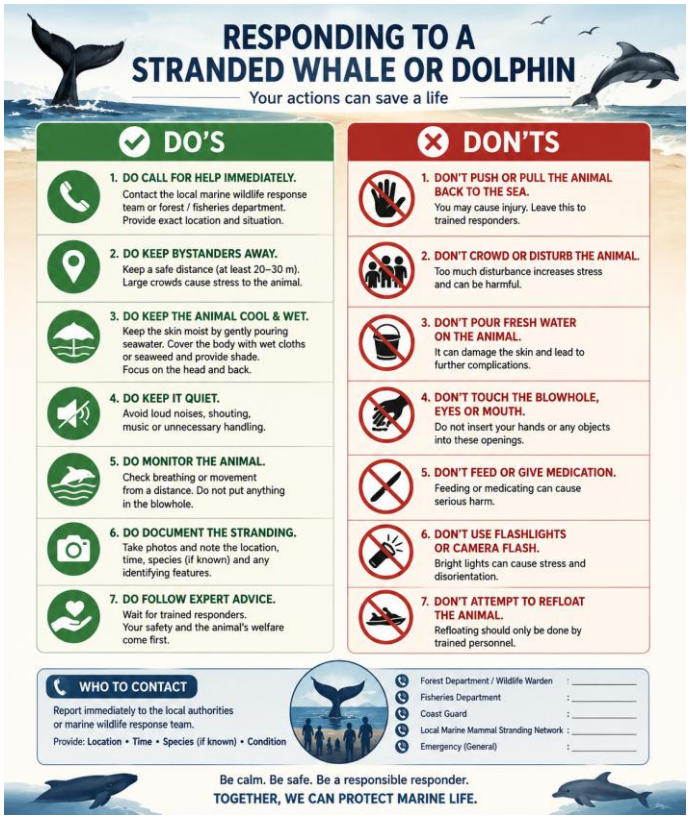
Other cetaceans of the Kerala coast *occasional sightings*

Beyond these, several more turn up in occasional sightings and strandings: the *Blue Whale* (Balaenoptera musculus, the largest animal ever to have lived) and *Sperm Whale* (Physeter macrocephalus) in deep offshore water; *Killer Whale* (Orcinus orca) and *Risso's Dolphin* (Grampus griseus); and the smaller *Spinner*, *Pantropical Spotted* and *Bottlenose* dolphins over the shelf and offshore. Name them as a group; each good sighting adds to a still-incomplete picture.

Smooth-coated Otter *Lutrogale perspicillata*.

- **Ecological Narrative:** Where the dolphins and whales belong to the open sea, the smooth-coated otter rules the dynamic interface between fresh water and coast, the rivers, estuaries, mangroves and backwaters of Kerala, feeding mainly on fish, crabs and prawns. Otters are a sign of healthy, prey-rich waters. They live in family groups that mark territory with calls and scent, and are active, curious animals often seen swimming, grooming and playing together. Their weak point is habitat: as wetlands are drained, degraded and polluted, otters vanish, which makes wetland conservation central to their future.
- **Conservation Status & Threats:** Listed as Vulnerable.

A note on the dugong: *India's only marine plant-eater, the dugong (Dugong dugon), is often mentioned in the same breath as marine mammals, but it does not occur along the Kerala coast. Its Indian strongholds are the Gulf of Mannar, Palk Bay and the Andaman & Nicobar Islands, where it grazes seagrass. Mention it as national context, not a Kerala sighting.*



4. Practical Toolkit for the Field

Where and When to Look

- **Estuaries & bar-mouths (Kochi, Azhikode, Munambam, Kollam):** the best bet for coastal dolphins, humpback and bottlenose, feeding on tide-concentrated fish, year-round; early morning and late afternoon are often most active.
- **Backwaters, river mouths & mangroves:** smooth-coated otters in family parties, plus feeding dolphins at the productive mixing zones.
- **Offshore & shelf waters (boat trips):** the realm of the whales, Bryde's whale most likely, and of spinner, spotted and other dolphins; better around the monsoon's productive pulses.

Reading the Environment

You won't always get a textbook view; behaviour and shape at the surface are your best clues.

- **A tall 'blow' far out** = a large whale (Bryde's, or rarely blue); a low, quiet roll with a small hooked fin and no fluke-up = likely Bryde's whale.
- **Leaping, bow-riding, beaked animals in a lively group** = dolphins; spinning leaps point to spinner dolphins.
- **A plain, finless, unhurried roll with little splash** = Indo-Pacific finless porpoise. Look carefully, it is easily missed.
- **Heads-up, playful animals in a river or backwater group** = smooth-coated otters, not a marine cetacean.

Field Etiquette & Responsible Code of Conduct

- Approach slowly and predictably; keep your distance and let the animals set the terms.
- Never chase, encircle, separate, or block the path of the animals; take special care around calves.

- Cut engine noise, limit your time with any group, and never feed or touch wild dolphins.
- Call the Forest / Fisheries Department, Coast Guard or a trained rescue group first; do not refloat the animal yourself.
- Keep the crowd and noise back; keep the blowhole clear of water; let trained responders lead.
- Report dead animals too. They still need a post-mortem and proper disposal.

Managing Expectations

Be honest about the odds. Coastal dolphins at the estuaries and otters in the backwaters are your realistic offerings; whales are an offshore bonus, never a promise. A guide who explains the search, the tides, the productivity, the behaviour, turns even a quiet day into a good story, and a genuine sighting into a thrilling one.

5. Quick-Reference Summary Table

A field cheat-sheet for the headline species. IUCN statuses are global assessments; where a species is not found in Kerala, that is noted.

Species	Group	IUCN status	Best chance in Kerala	The one fact to remember
Indian Ocean Humpback Dolphin	Coastal dolphin	Endangered	Estuaries & bar-mouths, year-round	A hump at the base of the fin; sticks close to home for years.
Indo-Pacific Finless Porpoise	Porpoise	Vulnerable	Shallow inshore waters	No dorsal fin and no beak; shy, and easy to miss.
Indo-Pacific Bottlenose Dolphin	Dolphin	Near Threatened	Coastal waters	The classic, acrobatic, bow-riding dolphin.
Spinner Dolphin	Dolphin	Least Concern	Offshore & shelf waters	Leaps and spins on its own axis in mid-air.
Bryde's Whale	Baleen whale	Least Concern	Productive coastal/offshore waters	Stays in warm tropical seas all year, lunging through sardine shoals.
Blue Whale	Baleen whale	Endangered	Deep offshore (Arabian Sea)	The largest animal that has ever lived on Earth.
Sperm Whale	Toothed whale	Vulnerable	Deep offshore; sometimes stranded	Dives over 1 km down for an hour to hunt squid in the dark.
Killer Whale (Orca)	Toothed whale	Data Deficient	Offshore, occasional	Apex predator living in life-long matrilineal pods.
Smooth-coated Otter	Otter (fissiped)	Vulnerable	Rivers, backwaters & mangroves	Uses stones to crack shellfish; lives in playful family groups.
Dugong	Sirenian	Vulnerable	Not in Kerala — Gulf of Mannar, Palk Bay, Andamans	India's only marine plant-eater; the original 'sea cow'.

6. Chapter Glossary

- **Cetacean:** any whale, dolphin or porpoise, fully aquatic marine mammals.
- **Baleen vs toothed whale:** baleen whales filter small prey through keratin plates; toothed whales have teeth and hunt individual prey.
- **Echolocation:** biological sonar, clicks whose echoes reveal prey and surroundings in dark or murky water.
- **Blowhole:** the nostril(s) on top of a cetacean's head, for quick breathing at the surface.
- **Blubber:** the thick fat layer that insulates, stores energy and adds buoyancy.
- **Pod:** a social group of dolphins or whales.

- **Fission-fusion:** a flexible society in which group membership changes as individuals join and leave.
- **Matrilineal pod:** a long-term group organised around related females, as in killer whales.
- **Convergent evolution:** unrelated groups evolving similar features to meet the same challenge (e.g., fish-like shape).
- **Site fidelity:** the tendency of an animal to stay within, or return to, a small home range.
- **Whale pump / whale fall:** the recycling of nutrients by whales' waste at the surface, and the deep-sea feast created by a sunken carcass.
- **Stranding:** when a marine mammal comes ashore or into shallow water and cannot return to deep water unaided.

7. Sources and Further Reading

This chapter synthesises information from the following:

- **Marine Mammal Research and Conservation Network of India** (marinemammals.in) - Indian species lists, identification and conservation guidance.
- **ICAR–Central Marine Fisheries Research Institute (CMFRI)** - Indian marine-mammal records, strandings and research.
- **Jefferson, Webber & Pitman,** *Marine Mammals of the World: A Comprehensive Guide to their Identification*.
- **Würsig, Thewissen & Kovacs (eds.),** *Encyclopedia of Marine Mammals*; and the *Handbook of Whales, Dolphins and Porpoises of the World*.
- **IUCN Red List** — global conservation status of each species; and the Wild Life (Protection) Act, 1972, CITES, CMS and IWC for the legal framework.
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Note: *marine-mammal taxonomy, status and distribution keep changing as new research and records appear, so treat this as a living document and refresh a fact if a guest queries it. Drafting and illustration were supported by AI tools and reviewed for accuracy.*

CHAPTER 5

BIRDS OF KERALA'S WETLANDS AND COAST

A Field-Oriented Lecture Note for Tour Guides

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How to Use This Chapter: *This chapter introduces birds as groups of ducks, pelicans, flamingos, darters, rails and jacanas, kingfishers, raptors, waders, terns and gulls, and dwells on a few charismatic representatives from each, every one with a memorable hook, its ecology and its migration story. Two short framing sections on the monsoon, migration and tides give a narrative spine, and an optional module covers the true seabirds of the open sea.*

In This Chapter

1. Introduction & Coastal Context

Kerala sits on the south-west shoulder of India, pressed between the Arabian Sea and the Western Ghats. Between mountain and sea runs a ribbon of water: estuaries, lagoons, backwaters, paddy-flooded 'Kole' lands and mangrove pockets, stretching almost the length of the state. For birds this ribbon is a lifeline. Kerala has recorded well over 500 species; a systematic, state-wide Kerala Bird Atlas (2015–2020) which is among the most detailed bird atlases attempted anywhere in India, mapped this diversity square by square. Roughly a fifth of these species are waterbirds, and it is these your visitors see most easily.

Three Kerala wetlands are recognised internationally under the Ramsar Convention: Vembanad–Kole, Ashtamudi and Sasthamkotta. The *Vembanad–Kole* complex is the largest Ramsar site in India, about 1,500 square kilometres, fed by ten rivers, and in winter holds one of the three largest congregations of waterfowl in the country. Further north, the *Kadalundi-Vallikkunnu Community Reserve* which is the only Community Reserve in the state, forms a critical wintering and 'refuelling' stop for migratory shorebirds. Smaller but vital sites include the Kole wetlands of Thrissur and Malappuram, and estuarine mudflats at Changaram, Chempakasheri, Purathur, Kattampally, Veli-Akkulam, Mangalavanam and the Kadalundi estuary.

There is heritage here too. The ornithologist Sálim Ali, the 'Birdman of India', surveyed the birds of old Travancore and Cochin in the 1930s and later wrote *Birds of Kerala*; the modern standard reference, *Birds of Kerala: Status and Distribution* (Sashikumar, Praveen J., Palot & Nameer, 2011), builds on that legacy.

The Rhythm of the Year: Monsoon, Migration and Tides

2. The rhythm of the year: monsoon, migration and tides

Before any species, give your guests the three forces that move the birds. Master these and every sighting has a story.

The monsoon as the metronome

In Kerala the monsoon, not winter, sets the calendar. The south-west monsoon (roughly June to September) floods the Kole and paddy landscapes into vast feeding grounds, triggers the breeding season of resident birds such as the herons, egrets, storks, darters and cormorants that gather to nest in colonies, and drives seabirds close to the coast. So, resident 'heronries' are a monsoon-and-post-monsoon spectacle, quite separate from the winter migrants.

Migration and the flyway

A flyway is a great aerial highway between northern breeding grounds and southern wintering grounds. Kerala lies at the southern end of the Central Asian Flyway, which links the Arctic tundra and the steppes and high plateaus of Central Asia to the Indian Ocean coasts. The plovers, sandpipers, ducks and terns on a December mudflat were, weeks earlier, in Siberia, Mongolia or on the Tibetan Plateau. Migrants arrive from September to October, peak from November to February, and depart by March to April. A winter cruise therefore gives the richest mix: residents plus the full cast of visitors.

Tides - the shorebird's clock

On the coast, the tide rules. Waders feed on exposed mudflats at low tide, then, as the sea covers the mud, they crowd together into dense, spectacular high-tide roosts on the last dry sandbars. A guide who reads a tide table delivers far better birding: aim for a falling or low tide to watch feeding, and time a rising tide to witness thousands of waders packed shoulder to shoulder. It is one of the great sights of the coast and a phenomenon most casual tourists never even know to look for.

Why These Birds Matter: Ecosystem Services

Visitors love birds for their beauty; a good guide can also say, in a sentence, why they matter. Waterbirds are working parts of the wetland.

- **Bio-indicators:** sensitive to pollution, water level and food, a rich bird community signals a healthy wetland; a crashing one like Kerala's declining darters and sea-eagles is an early warning.
- **Nutrient cycling:** by feeding in the water and depositing droppings on land and in colonies, birds move nutrients around, fertilising the productivity that ultimately feeds fish and people.
- **Ecosystem engineers:** colonial nesters shape heronry vegetation and soils; burrowers and probing waders turn over sediments, keeping wetlands dynamic.
- **Natural pest control:** egrets, pond-herons and waders consume vast numbers of insects, crabs and paddy pests.
- **Seed dispersal:** ducks and other waterbirds carry aquatic-plant seeds between wetlands, helping habitats regenerate.
- **Fisheries and food security:** the wetlands that feed the birds feed local fisheries; the two rise and fall together.
- **Ecotourism value:** this is your own livelihood and birds sustain guiding and boating incomes and give communities an economic reason to protect wetlands.

Pressures, Trends and Conservation

It is honest and it makes a better talk to admit these birds are under pressure. Long-term counts (the Asian Waterbird Census, the Vembanad Waterbird Count, district counts) have flagged declines: falling migratory-bird numbers in the Kole, stressed coastal shorebird sites, a declining Oriental Darter, and breeding White-bellied Sea-Eagles down by nearly a third in three recent seasons.

The drivers are familiar: reclamation of wetlands for building and farming; sand mining and altered flows that change estuarine salinity and structure; pollution from sewage, agriculture and solid waste; the growing burden of plastic and discarded fishing gear ('ghost gear') that entangles birds; loss of the tall shoreline trees raptors and colonial birds nest in; and disturbance including, ironically, from birdwatchers and photographers who crowd nests and roosts. Migration itself exacts a toll: studies on the Kerala coast have documented injuries in migratory waterbirds worn down by the journey.

A Kerala 'One Health' story: bird flu in the backwaters

One issue is worth handling with care because it is topical, local and practical. Kerala's wetland districts of Alappuzha and Kottayam (the Kuttanad region) have seen recurrent outbreaks of

highly pathogenic avian influenza (H5N1) since 2014, typically coinciding with the arrival of migratory birds and spread by the traditional practice of herding domestic ducks across flooded rice paddies. Outbreaks have triggered mass culls of tens of thousands of ducks, hitting the famous Kuttanad duck economy hard. For a guide the message is simple and responsible: it is a reminder of how wild birds, domestic animals and people share one landscape and one health, and a good reason to never handle sick or dead birds and to steer guests likewise.

The bright spots

Leave your guests with hope. Kerala created India's model Community Reserve at Kadalundi-Vallikkunnu, putting local people at the centre of protection; three wetlands hold Ramsar status; and the Spot-billed Pelican's recovery shows that protecting a few colonies works. A remarkable citizen-science culture, the Kerala Bird Atlas, the many local birding collectives, and platforms such as *eBird and Bird Count India*, now generates the data that drives conservation, and the *Asian Waterbird Census* each January is something guests can even take part in. Kerala's vibrant rarity culture adds sparkle: recent headline finds include India's first *Laughing Gull*, recorded in the state in 2024. Encouraging visitors to log sightings responsibly turns a tour into a small act of science.

3. Spotlight Series: Flagship Species & Case Studies

Ducks and Waterfowl (family Anatidae)

Ducks are the crowd-pleasers of any wetland. Kerala's fall into residents that breed here and winter migrants from the north. A useful field split is between *dabblers* (feeding at the surface, up-ending tail-in-air) and *divers* (vanishing underwater). Four ducks tell the whole story.

Lesser Whistling-Duck *Dendrocygna javanica*

- **Ecological Narrative:** Chestnut-brown and long-necked, this is the most abundant and reliable duck across Kerala's wetlands - a resident that breeds here. It does not quack but gives a soft, musical whistle, usually as a flock lifts off. Despite being a duck it perches in trees and nests in tree holes (a 'tree duck'). Highly gregarious, it rafts in dense flocks on paddy and lily-ponds, feeds on seeds, grain and aquatic plants, and is active into the night. Abundant whistling-ducks signal a healthy, food-rich wetland.
- **Conservation Status & Threats:** Least Concern and thriving.

Garganey *Spatula querquedula*

- **Ecological Narrative:** A small, neat dabbling duck, among the most numerous migratory ducks reaching India. Remarkably, essentially the entire breeding population, right across Europe and temperate Asia, abandons the north and moves to Africa, the Indian subcontinent and South-East Asia. Garganey are nocturnal migrants, travelling by dark and resting on open water by day. The drake shows a bold white crescent over a chocolate head; it feeds by delicately skimming the surface rather than up-ending.
- **Conservation Status & Threats:** Least Concern, but, like every migrant, dependent on a chain of healthy wetlands.

Ruddy Shelduck *Tadorna ferruginea*

- **Ecological Narrative:** Glowing orange-brown with a pale head, this is one of the handsomest waterfowl to visit India, known here as the Brahminy Duck. It threads through Sanskrit lore as the chakravaka pair, devoted lovers said to call across the water through the night. Ecologically it is an extreme athlete: breeding on the lakes of Central Asia and the Tibetan Plateau and wintering on the Indian plains, it must cross the Himalaya. Satellite-tracking records mean maximum heights around 5,600 m and close to 6,800 m, into thin, oxygen-poor air. In Kerala it is scarcer than in the north; look for pairs on larger backwaters and estuaries, giving a loud, honking call.
- **Conservation Status & Threats:** Not specified in source material — verify current IUCN status before publication.

Knob-billed Duck (Comb Duck) *Sarkidiornis melanotos*

- **Ecological Narrative:** One of India's largest, oddest ducks, glossy blue-black above, white below. The drake carries a curious fleshy knob or 'comb' that swells in the breeding season and shrinks afterwards. A 'perching duck', at home in trees, it nests in tree holes and breeds during and after the monsoon.
- **Conservation Status & Threats:** Least Concern globally but genuinely scarce in Kerala. Round out the group by simply naming the other winter dabblers guests may meet: Northern Pintail, Northern Shoveler, Eurasian Wigeon, Common Teal, and the tiny resident Cotton Pygmy-Goose.

Pelicans (family Pelecanidae)

Spot-billed Pelican *Pelecanus philippensis*

- **Ecological Narrative:** Few birds delight tourists more than a pelican scooping a pouch-full of water and fish. The Spot-billed Pelican, grey-white, with a row of dark spots along the upper bill and a pink throat pouch, is the pelican of Kerala's larger backwaters. It fishes by dipping its bill-pouch while swimming; unlike the Great White Pelican it does not gather in huge feeding flocks, but small groups will line up and drive fish into the shallows which is simple cooperative fishing.
- **Conservation Status & Threats:** Vulnerable, it recovered, improving to Near Threatened, thanks to protection of tree-top colonies in southern India (Kokrebellur, Uppalapadu, Nelapattu), where it nests beside villages. Keep groups at a respectful distance; colonies are easily spooked.

Flamingos (family Phoenicopteridae)

Greater Flamingo *Phoenicopterus roseus*

- **Ecological Narrative:** Tall, rose-flushed and unmistakable, the Greater Flamingo stops every tourist in their tracks. Two facts make it a perfect talking point. Its pink colour is dietary: flamingos hatch grey and turn pink only because their food, the algae, brine shrimp and other invertebrates, is rich in natural pigments (carotenoids). And it is a filter-feeder that turns its bill upside-down and pumps water through comb-like plates, straining out food much as a whale does with baleen. In Kerala it is a scarce, irregular winter visitor (first state records only in 1991), favouring saline and brackish coastal wetlands, mostly in the north and centre, often as small groups of grey immatures,

sometimes birds carried south from the Rann of Kutch and disoriented by monsoon winds. Mention it as a rare treat; never promise one.
- **Conservation Status & Threats:** Least Concern under current IUCN status.

Darters and Cormorants: The Underwater Spear-Fishers

Along every backwater you will see dark, long-necked birds perched with wings held open, as if drying washing. These *cormorants* and their relative the *darter* have **wettable** feathers: instead of trapping air like a duck's plumage, their soaked feathers let them sink and swim underwater after which they must perch and spread their wings to dry. Kerala's common cormorants are the Little and Indian Cormorants; the star is the darter.

Oriental Darter *Anhinga melanogaster*

- **Ecological Narrative:** Swimming with only its snake-like neck above the surface, the darter hunts with a piece of natural engineering: a hinge in the neck (a kink at the eighth and ninth vertebrae) lets it shoot its head forward like a loosed spring and impale a fish underwater, then surface, flick the fish off the bill and swallow it head-first. A resident of Kerala's backwaters, breeding colonially in the monsoon. It is listed as
- **Conservation Status & Threats:** Near Threatened, with declines noted in Kerala's own waterbird counts. As a top fish-predator it is an indicator of wetland health, a flagship sepcies whose fortunes you can tie to the whole backwater your guests are cruising.

Rails, Swamphens and Jacanas: The Reed-Walkers

Push past the open water into the reeds and lily-mats and a different cast appears, birds that walk on vegetation rather than swim. They are easy crowd-pleasers because they are colourful, comical and close.

- **Grey-headed Swamphen** *(Porphyrio poliocephalus)* is a big, gorgeous purple-blue rail with a red bill and forehead shield, clambering through reeds on huge red feet; watch it lift food to its bill in one 'hand' like a person — a guaranteed delight.
- **White-breasted Waterhen** *(Amaurornis phoenicurus)* is the tail-flicking, white-fronted rail of every ditch and pond edge, famous for its loud, repetitive dawn and dusk calls, often heard long before it is seen.
- **Common Moorhen & Eurasian Coot** *(Gallinula chloropus / Fulica atra)* is the everyday 'water-hens' of open ponds; the coot, all black with a white face-shield, gathers in rafts on larger wetlands in winter.
- **Ruddy-breasted & Baillon's Crakes** *(Zapornia spp.)* are small, skulking rails that reward patience at reed edges. Good 'expert' birds to search for when a group wants a challenge.

Pheasant-tailed & Bronze-winged Jacanas *Hydrophasianus chirurgus / Metopidius indicus*

- **Ecological Narrative:** Jacanas have absurdly long toes that spread their weight so they can walk across floating leaves, seeming to trot on the water itself. The Pheasant-tailed Jacana grows a spectacular sickle of a tail in breeding plumage. Their showstopper is behavioural: sex-role reversal. The female is larger, holds a territory and mates with several males (polyandry); each male then does the work, building the floating nest, incubating the eggs and guarding the chicks, even sheltering tiny young beneath his wings. It flips the usual bird story on its head and never fails to surprise an audience.

Kingfishers: Jewels of the Waterline

Kerala has a superb spread of kingfishers across two families ('river' kingfishers and larger 'tree' kingfishers), and they make a perfect, colour-packed segment. Introduce them as a set:

- **Common Kingfisher** *(Alcedo atthis)* is the tiny one, a blur of cobalt and orange that perches low and dives for small fish; the classic 'first kingfisher'.
- **White-throated Kingfisher** *(Halcyon smyrnensis)* is the ubiquitous one, turquoise back, chestnut body, white bib, loud laughing call; often far from water, hunting lizards and insects too.
- **Stork-billed Kingfisher** *(Pelargopsis capensis)* is the backwater giant, a heavy bird with an enormous blood-red bill, shy and local along wooded waterways; always a highlight.
- **Pied Kingfisher** *(Ceryle rudis)* is the acrobat with black-and-white, and one of the very few birds that can hang in a steady hover over open water before plunging, so it needs no perch and can fish far from shore.
- **Black-capped Kingfisher** *(Halcyon pileata)* is the winter migrant, a stunning purple-blue bird of coastal creeks and mangroves, present mainly in the cooler months; a prized sighting.
- **Collared Kingfisher** *(Todiramphus chloris)* is the mangrove specialist, turquoise-and-white, largely confined on this coast to mangroves and tidal creeks (around Kochi, Kannur and other pockets); a genuine habitat-indicator bird for guides working the mangroves.

Raptors: Hunters of Shore and Marsh

Birds of prey add drama. Three make their living from the water and three more from the marsh and the flocks above it.

Osprey *Pandion haliaetus*

- **Ecological Narrative:** One of very few truly worldwide raptors and an obligate fish-eater. Watch it hover, then plunge feet-first in a burst of spray. Nearly everything about it is engineered for the job: a reversible outer toe for a two-and-two grip on a slippery fish, spiny spicules on the foot-soles, closable nostrils and dense oily plumage. Northern breeders migrate south; Kerala hosts wintering Ospreys on coasts, estuaries and larger backwaters from about October to April. Its recovery after the pesticide DDT was banned is a textbook conservation success.
- **Conservation Status & Threats:** Least Concern under current IUCN status.

White-bellied Sea-Eagle *Haliaeetus leucogaster*

- **Ecological Narrative:** Big and striking, grey-and-white, the apex predator of the coast. It takes fish and sea snakes from the surface but will also seize waterbirds. Pairs mate for life, build huge stick nests high in tall trees in Kerala especially mango and banyan, most facing west toward the sea and give a loud, goose-like honking. As a top predator it is an indicator species, which makes a recent Kerala study sobering: surveyors recorded a 32% decline in breeding pairs over just three seasons (2021–2023), most nests on unprotected private or temple land. Still
- **Conservation Status & Threats:** Least Concern globally, but locally under real pressure from the loss of tall shoreline trees and disturbance.

Brahminy Kite *Haliastur indus*

- **Ecological Narrative:** The most frequently seen coastal raptor: rich chestnut with a clean white head, wheeling over harbours and estuaries, snatching fish scraps and crabs from the surface. Culturally it is linked to Garuda, the divine eagle, a connection south-Indian guests recognise. Common; the perfect 'first raptor' before you look for the scarcer sea-eagle and Osprey.
- **Conservation Status & Threats:** Least Concern

Western Marsh Harrier *Circus aeruginosus*

- **Ecological Narrative:** A winter visitor to the Kole and other marshes, the marsh harrier hunts unlike the others, flying low and slow, wings held in a shallow V, drifting back and forth over the reeds to flush and ambush frogs, small birds and rodents by surprise. Watch a harrier work a reedbed and the whole marsh reacts: coots dive, ducks bunch, and you can read the predator's path by the panic ahead of it.
- **Conservation Status & Threats:** Least Concern.

Peregrine Falcon *Falco peregrinus*

- **Ecological Narrative:** The peregrine is the fastest animal on the planet, reaching well over 300 km/h in its hunting 'stoop' — a folded-wing dive onto flying prey. In winter, peregrines patrol the coast and hunt the wader and pigeon flocks. If you ever see a packed mudflat erupt all at once into a tight, wheeling 'panic ball', scan the sky: a peregrine (or the everyday, ubiquitous Black Kite scavenging nearby) is usually the cause. That mass evasive swirl is one of the most electrifying spectacles the coast offers.
- **Conservation Status & Threats:** Least Concern.

Waders and Shorebirds: The Long-Distance Champions

The best material for astonishing a group. These small-to-medium birds, plovers, sandpipers, godwits, stilts, curlews, scuttle and probe across estuarine mud. To the casual eye they are 'little brown birds'; the truth is extraordinary. Many breed in the Arctic tundra or Central Asian steppe and fly the length of a continent, twice a year, to feed on Kerala's mud. Sites such as Kadalundi, the Kole wetlands and the Changaram mudflats can host tens of thousands of these travellers in winter best seen packed into a high-tide roost. The key idea is refuelling: migrants leapfrog between wetlands, landing lean and 'fattening up' on the rich invertebrate life of the mud before the next leg. A degraded mudflat is a broken link in a chain that reaches to Siberia.

Bar-tailed Godwit *Limosa lapponica*

- **Ecological Narrative:** The showstopper of the whole talk. The Bar-tailed Godwit makes the longest non-stop migratory flight known for any bird, and the longest journey without feeding by any animal. In 2022 a satellite-tagged juvenile flew about 13,560 km from Alaska to Tasmania in eleven days, without once landing, eating or drinking. To do it, the bird nearly doubles its body weight in fat and even shrinks its own digestive organs to save weight, burning through more than half its mass in the air. The godwits reaching western India belong to more westerly Siberian populations, so those are not the record-breakers themselves but it is the same species, and the story is entirely true.

- **Conservation Status & Threats:** Near Threatened and declining, as the tidal mudflats it needs are reclaimed. Also look for the Black-tailed Godwit (also Near Threatened), which favours the Kole and freshwater wetlands.

Great Knot *Calidris tenuirostris*

- **Ecological Narrative:** A stocky, medium-sized sandpiper and one of the most globally threatened shorebirds you can hope to see here. It breeds in the mountains of north-east Siberia and winters on Indian Ocean coasts; a satellite-tagged bird was tracked reaching Kerala's coast after a journey of more than 9,000 km. Its steep global decline is driven by the loss of the tidal 'refuelling' mudflats it depends on around the Yellow Sea. A Great Knot on a Kerala shore is a privilege and a powerful way to explain why distant mudflats a continent away decide whether these birds survive.
- **Conservation Status & Threats:** it is listed as Endangered under IUCN status.

Eurasian Oystercatcher *Haematopus ostralegus*

- **Ecological Narrative:** Boldly black-and-white with a long, straight, carrot-orange bill, the oystercatcher is easy to identify and a real prize on this coast, where it is an uncommon-to-scarce winter visitor. That heavy bill is a precision tool for prising open shellfish and probing for marine worms; individuals even develop different bill shapes depending on whether they 'hammer' or 'stab'. Now
- **Conservation Status & Threats:** Near Threatened and declining, so a sighting is one to celebrate.

Crab Plover *Dromas ardeola*

- **Ecological Narrative:** One of the most special birds a guide can show on the south-west coast: the sole member of its family (Dromadidae), gleaming white with black wings and a heavy tern-like bill. It winters on the coasts of peninsular India and Lakshadweep but breeds nowhere near here. Its colonies are confined to islands around the Arabian Sea, Persian Gulf, Red Sea and Somalia, where it does something no other wader does: it digs a burrow in the sand and lets the warmth of the sun-heated sand help incubate its single egg, freeing the adults from constant sitting; the young are then fed at the nest for an extended period. A crab specialist, often hunting at dawn, dusk and night. In 2023 the first breeding in the Indian subcontinent was documented at Point Calimere, Tamil Nadu, genuinely recent natural history to share.
- **Conservation Status & Threats:** Least Concern.

Little Stint, Curlew Sandpiper, Common and Marsh Sandpipers, Common Greenshank and Redshank, Terek Sandpiper, Whimbrel, Eurasian Curlew, Pacific Golden and Grey Plovers, Kentish Plover, and the elegant residents *Black-winged Stilt* and *Pied Avocet are other possible species along Kerala's coastal zones*. One 'taxonomy is alive' aside for keener guests: the familiar *Lesser Sand-Plover* was recently split (2022–2023) into two species, the Siberian Sand-Plover and the Tibetan Sand-Plover, after DNA showed one of them is actually closer to the Greater Sand-Plover; both winter on Kerala's shores.

Terns and Gulls (family Laridae)

Over any estuary or harbour, two kinds of long-winged grey-and-white birds. Gulls are the sturdier, broad-winged scavengers that loaf on sandbars and follow boats, and in Kerala

mostly winter visitors, including the small Brown-headed and Black-headed Gulls, the slim Slender-billed Gull, the large 'Heuglin's'/Lesser Black-backed Gull, and the imposing *Pallas's Gull* (one of the world's largest gulls). Terns are the slimmer, sharper-winged, fork-tailed 'sea-swallows' that hunt by hovering and *plunge-diving* head-first. A few terns to single out:

- **Greater Crested Tern (Thalasseus bergii):** a big, shaggy-crested tern that cleverly shadows fishing boats for discarded bycatch; breeds on offshore islands, including in Lakshadweep, where it is protected in the PM Sayeed Marine Birds Conservation Reserve.
- **Caspian Tern (Hydroprogne caspia):** the largest tern in the world, with a massive blood-red bill — always a talking point.
- **Gull-billed Tern (Gelochelidon nilotica):** a stout-billed tern that breaks the rules. Instead of plunge-diving, it hawks insects, crabs and even small lizards over land and marsh.
- **Lesser Crested, Little, and the migratory Common and Whiskered Terns:** the everyday terns of coast and backwater, best introduced as a group.

A lovely closing comparison: terns include the greatest traveller of all, the *Arctic Tern*, which shuttles roughly pole to pole each year, the longest migration of any animal, though it is only a rare vagrant to Indian waters. It places the terns your guests are watching within the grandest migration story on the planet.

Storks, Ibises, Spoonbills, Herons, Egrets and Bitterns

The tall wading birds are unmissable, and each has a hook worth a sentence rather than a shrug of 'that's a heron'.

- **Asian Openbill** *(Anastomus oscitans)*: look closely at the bill. There is a permanent gap between the mandibles, an evolved tool for gripping and extracting apple-snails (Pila) and mussels, its main food; large numbers gather where snails are plentiful.
- **Painted Stork** *(Mycteria leucocephala)* is a spectacular pink-and-white stork that breeds in noisy tree-top colonies, a seasonal spectacle you can build a stop around.
- **Eurasian Spoonbill** *(Platalea leucorodia)*: watch the feeding: it sweeps its flat, spoon-tipped bill side to side through the water and snaps it shut the instant it touches prey — feeding by touch, not sight.
- **Black-headed Ibis & Glossy Ibis** *(Threskiornis melanocephalus / Plegadis falcinellus)*: down-curved bills for probing soft mud; the Glossy Ibis shines bronze-and-green in good light.
- **Indian Pond-Heron** *(Ardeola grayii)* or the 'paddy bird' is a drab, hunched brown bird on the bank that vanishes into a startling flash of white wings the instant it flies; a great before-and-after moment for guests.
- **Western Reef-Egret** *(Egretta gularis)* is a coastal specialist that comes in two forms: an all-dark morph and a white morph, foraging actively along the tideline and rocks.
- **Bitterns (Yellow, Cinnamon, Black)** *(Ixobrychus / Botaurus spp.)* are secretive reed-skulkers that freeze bolt-upright to hide; finding one rewards patience and marks you as a sharp guide.

Fill in with the everyday Little, Intermediate and Great Egrets, the Grey and Purple Herons, and the Little and Indian Cormorants. Many of these nest colonially in monsoon heronries, where their droppings return nutrients to the water and their bustle signals a productive wetland.

4. Practical Toolkit for the Field

Where and When to Look

A rough guide to what to look for at the wetlands guides most often visit:

- **Vembanad backwaters (Kumarakom, Pathiramanal):** whistling-ducks, cormorants, darter, swamphen and jacanas, egrets and herons, kingfishers, Brahminy Kite and terns; wintering ducks and, with luck, a Spot-billed Pelican.
- **Kadalundi–Vallikkunnu Community Reserve & estuary:** the shorebird headline site — godwits, plovers, sandpipers, stints, gulls and terns crowd the mudflats at high tide; an outside chance of Crab Plover, Great Knot or, rarely, Greater Flamingo.
- **Kole wetlands (Thrissur / Malappuram):** large numbers of ducks and waders in season, Black-tailed Godwit, painted storks and openbills, ibises, marsh harriers quartering the reeds — and a past haunt of stray flamingos.
- **Ashtamudi & the Kollam coast:** estuarine terns, gulls and waders, with the occasional Osprey hunting over open water.
- **Mangalavanam (Kochi) and mangrove pockets:** herons, egrets and a heronry, plus the mangrove-specialist Collared and Black-capped Kingfishers - convenient for city-based visitors.

Reading the Environment

Read birds by group and behaviour: Is it up-ending (dabbling duck) or diving? Perched with wings spread to dry (cormorant/darter)? Hovering and plunging (tern, Pied Kingfisher, Osprey)? Walking on lily-pads (jacana) or clambering reeds (swamphen)? Probing mud with a long bill (wader)? Quartering low over reeds (harrier)? Behaviour narrows things fast and tells a far better story than a rushed name.

Field Etiquette & Responsible Code of Conduct

- Keep your distance from nests, colonies and roosting flocks; if birds stop feeding, look up repeatedly or take flight, you are too close - step back.
- Never flush a flock for a better photograph; a panicked wader burns fuel it flew thousands of kilometres to store.
- Time the tide: fish and feed on a falling/low tide, and enjoy the massed high-tide roost from a respectful distance.
- Stay on boats, paths and viewpoints; avoid walking onto sensitive mudflats and into breeding areas.
- Take all litter, especially plastic and fishing line, away with you, and never handle sick or dead birds.
- Use binoculars and a scope rather than getting closer; log notable sightings on eBird responsibly, blurring locations of sensitive breeders.

Managing Expectations

Be honest about rarity. Whistling-ducks, cormorants, egrets, swamphens, common kingfishers, Brahminy Kites and common terns are near-certain; Ospreys, sea-eagles, marsh harriers and Stork-billed Kingfishers are likely at the right sites; flamingos, oystercatchers, Great Knot, Crab Plovers, Ruddy Shelducks and Comb Ducks are special and never guaranteed. Guests remember an honest guide who delivers a genuine surprise far more fondly than one who over-promises. Turn the search itself into the pleasure.

5. Quick-Reference Summary Table

A field cheat-sheet for the headline species. “LC” = Least Concern (IUCN). Seasons are a rough guide for Kerala.

Species	Group	Status	Best season	The one fact to remember
Lesser Whistling-Duck	Ducks	LC / common resident	All year	Whistles in flight; a duck that perches and nests in trees.
Garganey	Ducks	LC / common winter	Oct–Mar	Whole breeding population migrates; travels by night.
Ruddy Shelduck	Ducks	LC / scarce winter	Nov–Feb	The 'Brahminy Duck'; crosses the Himalaya near 6,800 m.
Knob-billed Duck	Ducks	LC / scarce	Jul–Dec	Male grows a fleshy 'comb' on the bill; nests in tree holes.
Spot-billed Pelican	Pelicans	Near Threatened	Nov–Mar	Scoops fish in a throat pouch; recovered from Vulnerable.
Greater Flamingo	Flamingos	LC / rare visitor	Dec–Mar	Filter-feeds bill-upside-down; pink from its food.
Oriental Darter	Darters	Near Threatened	All year	The 'snakebird'; spears fish with a spring-loaded neck.
Grey-headed Swamphen	Rails	LC / common resident	All year	Purple-blue reed-climber; holds food in one 'hand'.
Pheasant-tailed Jacana	Jacanas	LC / resident	Breeds monsoon	Walks on lily-pads; females mate with several males, males mind the eggs.
Stork-billed Kingfisher	Kingfishers	LC / resident	All year	Huge red dagger of a bill; a backwater giant.
Pied Kingfisher	Kingfishers	LC / resident	All year	Hovers steadily over water before plunging.
Osprey	Raptors	LC / winter	Oct–Apr	Reversible toe + spiny soles grip fish; a DDT-recovery icon.
White-bellied Sea-Eagle	Raptors	LC; declining in Kerala	All year	Coastal apex predator; 32% drop in Kerala breeding pairs (2021–23).
Western Marsh Harrier	Raptors	LC / winter	Oct–Mar	Quarters low over reedbeds hunting by surprise.
Peregrine Falcon	Raptors	LC / winter	Oct–Mar	The fastest animal on Earth; scatters wader flocks in panic.
Bar-tailed Godwit	Waders	Near Threatened	Oct–Apr	Longest non-stop flight of any bird: ~13,560 km.
Great Knot	Waders	Endangered / rare	Nov–Mar	A tagged bird flew 9,000+ km from Siberia to Kerala's coast.
Crab Plover	Waders	LC / scarce winter	Nov–Mar	Alone in its family; warm sand helps incubate its egg.

Species	Group	Status	Best season	The one fact to remember
Asian Openbill	Storks	LC / resident	All year	A gap in the bill built to prise open apple-snails.
Caspian Tern	Terns	LC / winter	Oct–Apr	The world's largest tern, with a carrot-red bill.

6. Chapter Glossary

- **Flyway:** a broad migration route between breeding and wintering grounds. Kerala lies at the south end of the Central Asian Flyway.
- **Migrant vs resident:** migrants breed elsewhere and only winter here; residents live and breed in Kerala year-round.
- **Dabbling vs diving duck:** dabblers feed at the surface and up-end (tail up); divers go fully underwater.
- **Wader / shorebird:** small-to-medium long-legged birds that feed on mudflats, mostly by probing for invertebrates.
- **High-tide roost:** the dense flock of shorebirds packed onto the last dry ground when the rising tide covers the mudflats.
- **Filter-feeding:** straining tiny food from water through comb-like plates, as flamingos do.
- **Bio-indicator:** a species whose health reflects the health of its whole environment.
- **Heronry:** a tree-top breeding colony of herons, egrets, storks, ibises and their kin, usually active in the monsoon.
- **Refuelling / staging site:** a wetland where migrants stop to feed and rebuild fat reserves mid-journey.
- **Ramsar site:** a wetland recognised as internationally important under the Ramsar Convention.
- **One Health:** the idea that the health of wildlife, domestic animals and people is linked — as in the Kuttanad bird-flu story.

7. Sources and Further Reading

This note synthesises information from the following authoritative sources, which you can consult to go deeper or verify a fact before a tour:

- **eBird** (ebird.org) - species accounts, Kerala checklists and the Kerala Bird Atlas.
- **Bird Count India** (birdcount.in) - the Kerala Bird Atlas, migration maps and the Asian Waterbird Census.
- **BirdLife International Data Zone** (datazone.birdlife.org) - global status, trends and the Bar-tailed Godwit migration account.
- **Birda** (app.birda.org) - concise species field guides.
- **Regional and peer-reviewed literature on Kerala and India** - Sálim Ali's work and 'Birds of Kerala: Status and Distribution' (Sashikumar, Praveen J., Palot & Nameer, 2011); shorebird studies at Kadalundi–Vallikkunnu and Changaram; the status of Greater Flamingos in Kerala; White-bellied Sea-Eagle nesting and decline in Kerala (Amal & Roshnath, 2025); Crab Plover breeding at Point Calimere (2023); the Lesser Sand-Plover split (Wei et al., 2022; IOU, 2023); the Great Knot tracked to Kerala; Ruddy Shelduck trans-Himalayan tracking (Parr et al., 2017); the Bar-tailed Godwit world-record flight (USGS/Guinness World Records, 2022); Malabar-coast pelagic surveys (Praveen J. et al.); and studies on recurrent H5N1 in Kuttanad (Chanda et al., 2025).

Optional Module: The Pelagic Dimension - True Seabirds off Kerala

This module is optional, include it only for guides who run offshore boat trips or work in Lakshadweep, since none of these birds is seen on an ordinary backwater or beach tour. It is a different world, and a thrilling one.

Unlike almost everything else in this note, Kerala's true seabirds are creatures of the south-west monsoon (roughly June–September), when rough seas and strong winds push open-ocean birds close to the Malabar coast, occasionally even onto beaches as 'wind-blown' birds. Dedicated offshore surveys off Kozhikode and the northern Kerala coast have shown a surprising richness of these ocean wanderers. The cast includes:

- **Noddies and pelagic terns:** the Brown Noddy is the commonest noddy here, moderately abundant in the monsoon, and the Bridled Tern, typically the most frequently recorded pelagic tern offshore, along with Lesser Noddy and the far-ranging Sooty Tern.
- **Shearwaters:** fast, stiff-winged birds that shear low over the waves, including the Persian (Tropical) Shearwater, Flesh-footed Shearwater and Wedge-tailed Shearwater in the eastern Arabian Sea.
- **Storm-petrels:** tiny, fluttering ocean birds that patter over the surface- Wilson's Storm-Petrel and the scarcer Swinhoe's Storm-Petrel.
- **Jaegers / skuas:** piratical seabirds that chase terns in the air until they drop their catch- Parasitic (Arctic) and Pomarine Jaegers have both been recorded harassing terns off the coast.
- **Boobies and frigatebirds:** the Brown Booby and, rarely, frigatebirds, more likely around the Lakshadweep islands than the mainland coast.
- **A wader that lives at sea:** the Red-necked Phalarope, which winters on the open ocean in rafts, spinning on the surface to stir up plankton.

For this world, the standard references are the Kerala state avifauna ('Birds of Kerala: Status and Distribution', 2011) and the published Malabar-coast pelagic surveys.

CHAPTER 6

THE BACKWATERS OF KERALA

Estuaries, Lagoons and Wetland Life Along the Coastal Plain

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> ***How to Use This Chapter:*** *This chapter gives you the working knowledge behind one of Kerala's signature landscapes, the backwaters. It moves from what the backwaters are and how they were formed, to the major systems a guest is likely to visit, to the two most-asked-about phenomena (changing water colour and night-time bioluminescence), to the distinctive farming systems of Kuttanad and Pokkali, and finally to tourism, livelihoods and conservation.*

In This Chapter

1. Introduction & Coastal Context

The Kerala backwaters are a chain of shallow, brackish lakes, lagoons, estuaries, tidal creeks, rivers and canals running along the state's coastal plain, mostly just behind the sandy shore of the Arabian Sea. Locally they are called kayals. Their water is brackish because freshwater draining off the Western Ghats mixes with saline water entering through tidal inlets, and because the balance between the two shifts sharply between the monsoon and the dry season, the backwaters are never quite the same system twice. They are best understood as a dynamic wetland network, threaded together with rivers, the open sea, farmland, mangroves, floodplains and human settlement.

Beyond their ecology, the backwaters knit together a closely interconnected rural and urban economy and culture. They sustain agriculture and food security (Kuttanad paddy, Pokkali rice, coconut, vegetables, ducks and household crops), fisheries and aquaculture, clam and shell-based livelihoods, traditional occupations such as net-making, boat-building and the coir sector, and more recently tourism and hospitality. Before the highway network expanded, canals and backwaters were the state's main transport routes, and they still form part of the West Coast Canal and National Waterway network today. Churches, temples, mosques, markets and villages have historically grown up along these water routes, making the backwaters as much a cultural landscape as an ecological one.

2. Core Concepts & Environmental Dynamics

How the Backwaters Were Formed

Kerala is a narrow strip of land pressed between the Western Ghats and the Arabian Sea. Numerous short, monsoon-fed rivers rush down from the Ghats, carrying water and sediment towards the coast. At the shoreline, waves, tides and currents rework this sediment into beaches, sand bars, spits and barrier islands. Where such a barrier partly seals off a river mouth or a shallow coastal embayment, the water trapped behind it becomes a lagoon or backwater lake, kept alive by tidal inlets that maintain its connection to the sea. The landscape seen today is the outcome of Holocene sea-level change, river deposition, and wave and tidal action, overlaid, in the last two centuries, by extensive human modification: reclamation, bunding, canal-cutting, port-building and settlement.

The seasons still govern this system. During the south-west monsoon, river discharge rises, salinity falls, and large quantities of suspended sediment and organic matter pour into the backwaters. In the dry season the sea reasserts itself: tidal penetration strengthens and many coastal stretches turn more saline. The backwaters are therefore best described not as one fixed habitat but as a seasonal freshwater–brackish–marine continuum.

A single backwater system typically strings together several distinct landforms:

- Shallow lagoons and estuarine lakes
- Tidal channels and river mouths
- Barrier beaches, spits and beach ridges
- Islands and river-built deltas
- Mudflats, marshes and mangroves
- Natural and artificial canals

- Low-lying paddy fields and reclaimed, embanked polders- locally padashekarams or kayal lands


Major Backwater Systems of Kerala

Vembanad Lake is Kerala's largest and most important backwater system, running through Kochi, Kumarakom, Kuttanad and Alappuzha and linked to a dense network of rivers and canals. Its southern reach holds the reclaimed paddy landscape of Kuttanad; its northern reach opens into the Kochi estuary and harbour. Vembanad–Kol is recognised as a Ramsar Wetland of International Importance, and it supports navigation, agriculture, fisheries, clam collection, bird habitat and tourism all at once.

Ashtamudi, in Kollam district, is Kerala's second major estuarine backwater. Its name literally means 'eight-branched', describing its palm-shaped outline. The Kallada River feeds it, and it opens to the Arabian Sea near Kollam. Ashtamudi is known for its estuarine fisheries, mangroves, islands, Chinese fishing nets, inland navigation and houseboat tourism, and it too is a Ramsar-listed wetland.

Beyond these two flagship systems lie a string of smaller but locally important backwaters: Kayamkulam Lake between Alappuzha and Kollam; the Paravur and Edava-Nadayara backwaters in the far south; Kadinamkulam and Veli-Akkulam near Thiruvananthapuram; the Poovar-Neyyar estuary; Chettuva and Kodungallur; Kallai-Canoli and Kozhikode; Kavvayi and Valiyaparamba in Kannur and Kasaragod; and the Chandragiri and Bekal stretches further north. Alappuzha, Kuttanad, Kumarakom, Ashtamudi, Munroe Island and Kumbalangi are the destinations most commonly marketed as backwater tourism hubs. Sasthamkotta Lake is often mentioned in the same breath as Kerala's Ramsar wetlands, but it is worth correcting a common guide's mix-up: Sasthamkotta is primarily a freshwater lake, not a brackish coastal backwater.

System	District(s)	Ramsar Status	Known For
Vembanad-Kol	Ernakulam, Kottayam, Alappuzha	Ramsar site	Largest backwater in India; houseboats, Kuttanad
Ashtamudi	Kollam	Ramsar site	Palm-shaped Lake; Chinese nets, houseboats
Sasthamkotta	Kollam	Ramsar site (freshwater)	Freshwater lake, not a true backwater

Kayamkulam	Alappuzha / Kollam	Not Ramsar	Fisheries, coir retting
Kavvayi-Valiyaparamba	Kannur, Kasaragod	Not Ramsar	Mangroves, quieter northern backwaters

The Changing Colours of the Backwaters

Guests often ask why the water looks different from one stretch to the next, or from one season to the next. The colour of backwater water is never fixed: it depends on sunlight, cloud cover, depth, the colour of the bottom, suspended sediment, dissolved organic matter, plankton, aquatic plants and pollution. Water-quality studies on Vembanad use measures such as chlorophyll-a, total suspended matter, turbidity and coloured dissolved organic matter to explain these shifts.

- Blue or blue-grey: open, relatively clear, deeper water reflecting the sky, with fewer suspended particles; cloud, shadow and surface waves can shift it towards steel-grey.
- Green: usually chlorophyll from phytoplankton or reflected vegetation. A moderate green is normal in a productive wetland, but an unusually thick, bright-green surface layer can signal an algal bloom or eutrophication.
- Yellow-brown or tea-brown: common during and after the monsoon, as rivers carry in clay, silt and organic particles and decaying vegetation releases coloured dissolved organic matter; this is often entirely natural, not pollution.
- Reddish, orange or rusty: caused by suspended mineral particles or dense blooms of pigmented microorganisms, including the dinoflagellate *Noctiluca scintillans*; not every red bloom is toxic, but dense blooms can alter oxygen levels and warrant caution.
- Dark brown or black: typical where organic decomposition is heavy, especially near peat-like kari soils, shaded canals and poorly flushed marshes; if it comes with a sewage smell, oil films, foam or dead fish, pollution or oxygen depletion is the likelier cause.

Water colour is a useful first impression, but only laboratory analysis can reliably separate a natural colour change from contamination, a point worth making honestly to guests who ask if the water is 'safe' or 'dirty'.

Ecological Importance and Ecosystem Services

Backwaters are highly productive because they receive nutrients from rivers, tidal water, farmland run-off and decomposing vegetation, and their salinity gradients create habitat for freshwater, brackish-water and marine organisms side by side. Mangroves, mudflats, shallow channels and submerged vegetation provide feeding, breeding and nursery habitat for prawns and shrimps, crabs, pearl spot (karimeen), mullets and other estuarine fish, clams, mussels and oysters, aquatic insects and plankton, and resident and migratory water birds. Documentation of the Vembanad–Kol wetland records hundreds of plant species, extensive phytoplankton diversity, and regular congregations of waterbirds that include large numbers of winter migrants.

In terms of ecosystem services, the backwaters store and gradually release monsoon water, help moderate floods, trap sediment and nutrients, support nutrient recycling and water purification, buffer parts of the coast against waves and erosion, sustain fisheries and agriculture, store carbon in mangrove and wetland soils, and maintain genetic diversity,

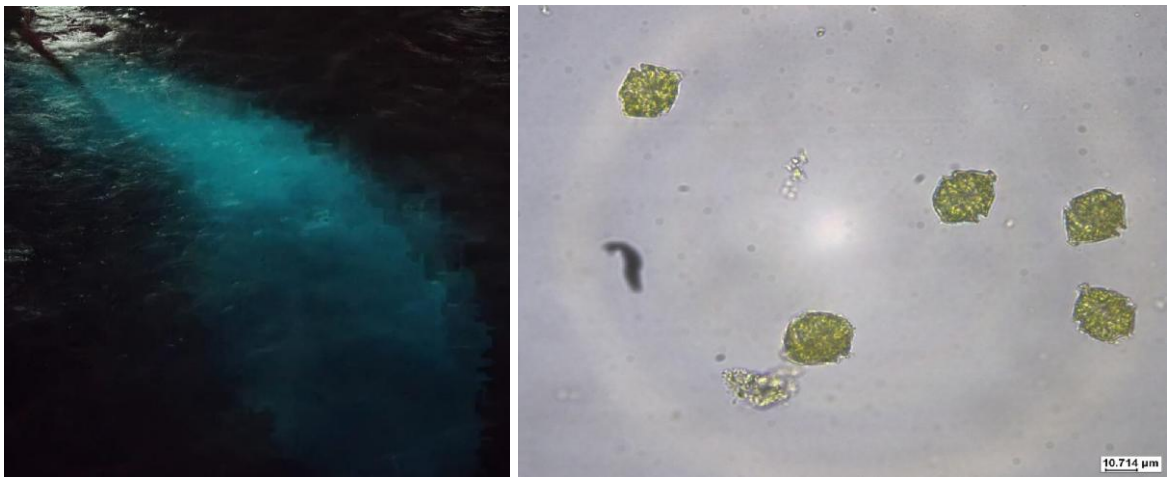
including salt- and flood-tolerant rice varieties. Kuttanad's wetland farming and water-management system also plays a significant regional role in controlling monsoon flooding and conserving water through the dry season.

The main ecological pressures are familiar ones: reclamation, encroachment, untreated sewage, industrial effluents, agricultural run-off, plastic waste, excessive dredging, invasive water hyacinth, overfishing and poorly managed tourism. None of these individually would be fatal, but together they explain why long-term water-quality trends in systems like Vembanad are watched so closely by researchers. Research on Vembanad has shown that reducing suspended matter, turbidity and coloured dissolved organic matter can substantially improve water clarity, a good evidence, if a guest asks, that the backwaters' health is not beyond repair.

3. Spotlight Series: Flagship Species / Case Studies

- **Bioluminescence** *(the kavaru of Kumbalangi)*

    - **The Story:** Bioluminescence is light produced by a living organism through a chemical reaction. In parts of the Kochi and Kumbalangi backwaters this is known locally as kavaru, or 'sea sparkle': water disturbed by a paddle, a fish, a boat hull or even a hand can suddenly flash blue or blue-green in the dark. The organism most often behind Kumbalangi's display is the microscopic dinoflagellate *Gonyaulax spinifera*; *Noctiluca scintillans*, responsible for daytime red-tinged blooms elsewhere, can also produce bioluminescent displays along the coast.
    - **Guiding Notes:** The display is visible only at night, and its strength depends on salinity, water temperature, nutrients and plankton abundance at the time — so set guest expectations that this is a natural, variable phenomenon rather than a guaranteed nightly show.



Left: Bioluminescence caused by *G. spinifera* in the Kumbalangi bloom area captured at night during March 2024
Right: Photomicrograph of *Gonyaulax spinifera* isolated from Kumbalangi bloom area

- **Kuttanad** *(farming below sea level)*

    - **The Story:** Kuttanad is a low-lying deltaic wetland at the southern end of Vembanad Lake, covering roughly 900 square kilometres of rivers, canals, paddy fields, marshes, ponds, reclaimed lake beds, village islands and garden land. Its rice country is built from three landform types- Karapadam (higher, less waterlogged land), Kayal lands (fields reclaimed from shallow lakes and enclosed by bunds into polders, including the well-known lettered blocks Q, R, S and T) and Kari lands (dark, peat-like, acidic low ground). Farmers enclose delta swamps and shallow backwaters with earthen bunds and pump the water out - fields that function much like the polders of the Netherlands, using strong outer bunds, sluice gates, pumps, drainage canals, collective farmer management and control of saline-water entry from Vembanad. Cultivation follows a tight calendar: strengthening the bund, closing sluices, pumping the field dry, preparing soil, sowing or transplanting, managing water, and harvesting before the next flood. Because the field sits below the surrounding rivers and canals, water cannot drain by gravity. Continuous bund maintenance and pumping are the basic conditions of farming here, not optional extras.
    - **Recognition & Significance:** In recognition of its traditional engineering, biodiversity, local knowledge and adaptation to a genuinely difficult coastal environment, the Kuttanad Below Sea Level Farming System was declared a Globally Important Agricultural Heritage System (GIAHS) by the FAO in 2013. Beyond rice, Kuttanad supports fish, ducks, livestock and household cultivation on its slightly elevated garden lands, which an integrated wetland farming system rather than a rice monoculture.

- **Pokkali Cultivation** *(the rice–prawn rotation)*

    - **The Story:** Pokkali is a traditional saline-wetland rice system practised mainly in the coastal tracts of Ernakulam and adjoining districts. It is easily confused with Kuttanad farming, so it is worth drawing the distinction for guests: Kuttanad is principally a below-sea-level freshwater or seasonally brackish polder system, while Pokkali agriculture is deliberately built around alternating freshwater and saline tidal conditions, using tall, flood- and salt-tolerant Pokkali rice. The calendar runs in three phases: April–May, when farmers shape the acidic, saline soil into raised mounds before the monsoon; June–November, when monsoon rain washes the salt off the mounds and rice is nursed, transplanted, grown to nearly two metres and harvested around October; and mid-November to April, when sluice gates reopen with rice stalks left standing, letting in tidal water and prawn larvae, with the decomposing rice residue feeding the prawns naturally.
    - **Significance & Pressures:** Pokkali matters beyond the plate: it conserves salt-tolerance genes, adapts agriculture to coastal salinity, sustains wetland biodiversity, and provides both a rice and aquaculture income from the same field. It also faces real pressure of labour shortages, urban encroachment, rising costs, and a pull towards replacing seasonal rice with year-round aquaculture.

4. Practical Toolkit for the Field

Where and When to Look

The backwaters are among Kerala's most important tourism assets. Typical visitor activities include houseboat (kettuvallam) cruises, canoe trips through narrow canals, village and homestay tourism, birdwatching and mangrove visits, recreational fishing and kayaking, watching the Chinese fishing nets at work, visits to Pokkali fields, traditional cuisine and seafood tourism, snake-boat races, and heritage visits to fishing settlements, coir villages and historic ports. Bioluminescence is a night-time phenomenon best sought at Kumbalangi, while Kuttanad's below-sea-level fields and Pokkali's rice–prawn rotation is best explained on-site, against the visible bund and canal.

Reading the Environment

Water colour is a genuine, if imperfect, guide to what is happening beneath the surface. Use the colour cues above to read a stretch of water at a glance, but avoid over-diagnosing from colour alone. A canal running noticeably higher than the paddy field beside it is the clearest visible sign of Kuttanad's below-sea-level farming at work.

Field Etiquette & Responsible Code of Conduct

Tourism creates markets for local food, handicrafts, coir products and farm produce, and employment for boat operators, cooks, guides, mechanics, homestay owners and small traders. But the same activity can damage the landscape it depends on. Sustainable backwater tourism rests on registered boats, proper sewage treatment, limits set by ecological carrying capacity, electric or low-emission vessels, community-owned enterprises, and a preference for smaller, canoe-based experiences over mass boat traffic, points a guide can usefully model in their own conduct on a tour.

- Keep boat numbers, engine noise, fuel handling and waste disposal to the minimum a stretch of water can absorb.
- Explain water-colour and bioluminescence accurately rather than sensationally, and help visitors see the backwaters as a working landscape, not only a scenic backdrop.
- Respect the livelihood rights of the communities who live on and off this water — farmers, fishers, clam collectors and boat operators alike.

Managing Expectations

Bioluminescence is a natural, variable phenomenon, not a guaranteed nightly show. Its intensity depends on conditions on the night itself. Water colour, similarly, shifts with season and cannot always be traced to a single cause without laboratory testing. Set these expectations honestly rather than promising a spectacle.

5. Quick-Reference Summary Table

A one-glance guide to Kerala's major backwater systems, their status and what each is known for.

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Vembanad-Kol backwater	Karimeen, black clam, migratory waterbirds	Best explored by houseboat or canoe around Kumarakom and Kuttanad	Kerala's largest backwater and a Ramsar site
Ashtamudi Lake	Estuarine fish, Chinese fishing nets	Visit near Kollam for palm-shaped estuary views and net demonstrations	Second major Ramsar-listed backwater
Kumbalangi (night)	Bioluminescent dinoflagellates (kavaru)	Go out after dark; disturb the water gently to trigger a flash	A natural, not guaranteed, nightly phenomenon
Kuttanad	Below-sea-level paddy, bunds, sluices	Point out the canal running higher than the field	A FAO-recognised Globally Important Agricultural Heritage System
Pokkali tracts (Ernakulam)	Rice–prawn rotation fields	Visit in the rice phase (Jun-Nov) or the prawn phase (Nov-Apr)	Same field yields both a rice and a prawn harvest each year

6. Chapter Glossary

- **Kayal:** the Malayalam term for a backwater lake or lagoon.
- **Polder:** land reclaimed from water and enclosed by bunds, drained and kept dry by pumping: the basic unit of Kuttanad and kayal-land farming.
- **Padashekaram:** a collectively managed paddy block in Kuttanad.
- **Karapadam / Kayal / Kari:** the three principal landform types of Kuttanad's rice country: higher land, reclaimed lake-bed, and peaty low ground respectively.
- **Bioluminescence / kavaru:** light produced by living organisms. in Kumbalangi, chiefly the dinoflagellate *Gonyaulax spinifera* visible as blue-green flashes in disturbed water at night.
- **GIAHS:** Globally Important Agricultural Heritage System, an FAO designation: Kuttanad's below-sea-level farming was recognised in 2013.
- **Ramsar site:** a wetland recognised as internationally important under the Ramsar Convention: Vembanad–Kol, Ashtamudi and Sasthamkotta all carry this status.
- **Kettuvallam:** the traditional Kerala houseboat, originally a rice barge, now the classic backwater tourism vessel.

7. Sources and Further Reading

- Ramsar Convention on Wetlands - designation and criteria for Vembanad–Kol, Ashtamudi and Sasthamkotta.
- Food and Agriculture Organization (FAO) - Globally Important Agricultural Heritage Systems (GIAHS) recognition of the Kuttanad farming system (2013).

- Water-quality research on the Vembanad estuarine system (chlorophyll-a, turbidity and coloured dissolved organic matter studies).
- Kerala Tourism - backwater tourism destinations and houseboat/canoe tourism data.
- World Wide Web

Note: tourism figures, water-quality data and conservation designations should be refreshed from current CMFRI and Kerala Tourism sources at each edition.

CHAPTER 7

MANGROVES AND THEIR SIGNIFICANCE

Kerala's Coastal Forests Between Land and Sea

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> ***How to Use This Chapter:*** *Mangroves are one of the easiest things on a Kerala backwater tour to point at and one of the easiest to under-explain. This chapter gives you what to say about what mangroves are and why they matter, the two flagship sites your guests are most likely to visit (Kadalundi–Vallikkunnu and the Vembanad Lake mangroves), and reference tables of the true mangrove species and their common associates, for when a curious guest wants a name for what they are looking at.*

In This Chapter

1. Introduction & Coastal Context

Mangroves are salt-tolerant plants that thrive in the intertidal zone of tropical and subtropical coasts, where they act as a natural coastal barrier between land and sea. They are facultative halophytes: they can tolerate saltwater, but they do not need it, given the choice, they would rather have freshwater, and their salt tolerance is best understood as an adaptation forced on them by their intertidal home rather than a preference. Adapted to waterlogged, high-salinity soils and to the extremes of tide, storm and sun, they deliver an outsized range of ecosystem services for their modest global footprint: coastal protection, biodiversity support and carbon storage among them. Recent research adds further roles to this list — mangroves help buffer local ocean acidification and coastal eutrophication, and act as natural traps for microplastics, quietly filtering out material that would otherwise wash further into the backwaters or out to sea.

India's mangrove cover stands at 4,991.68 km², about 0.15% of the country's total area, modest in extent, but ecologically disproportionate in importance. Of this, 29.33% is classed as very dense, 30.07% as moderately dense and 40.60% as open mangrove. The country hosts 46 true mangrove species across 14 families and 22 genera, though the latest assessments show a decline of 7.43 km² in cover since 2021, a reminder that even well-studied, well-publicised ecosystems can keep losing ground quietly. Kerala's mangroves matter well beyond their small area: they act as nursery grounds for fish, prawns, crabs and molluscs, and so support fisheries and local livelihoods directly and not just in the abstract. The Kannur mangroves, for instance, support a wide range of fish, bird and mammal species, and the same nursery role is played by the mangroves fringing the Vembanad Lake system, which offer refuge and breeding habitat to threatened terrestrial and aquatic species alike.

2. Core Concepts & Environmental Dynamics

A Natural Coastal Bio-shield

Mangroves act as a living bio-shield along the coast. Their dense, tangled roots reduce wave energy, slow storm surges, check coastal erosion and help prevent saline water from intruding into inland areas. This matters especially in Kerala, where settlements, roads, farmland and tourism infrastructure are all packed close to the coast and backwaters, there is very little buffer left except what the mangroves themselves provide.

Water Quality and Blue Carbon

Mangroves improve water quality by trapping sediments, pollutants and nutrients before these reach the backwaters and the sea, helping to maintain the health of Kerala's wetland systems, including globally important sites such as Vembanad–Kol and Ashtamudi. They are also significant blue-carbon ecosystems, storing carbon in their biomass and in waterlogged soils in a way that makes them genuinely useful allies in climate-change mitigation, not just a scenic backdrop, but working infrastructure for carbon storage and water quality alike.

Threats to Kerala's Mangroves

All of this significance is sharpened by the fact that Kerala's mangroves are now fragmented and under real pressure. Coastal development, land reclamation, aquaculture expansion,

agriculture, real-estate pressure and weak enforcement of protective regulation have together driven a serious decline, a point worth making plainly to guests, since the mangrove patch they are looking at today may well be smaller, or under more pressure, than it was a decade ago.

Zonation: Which Species Grows Where

The Vembanad Lake ecosystem holds approximately 600 hectares of mangrove cover, in patches at Mangalavanam, Vypin, Vallarpadam, Bolgatty, Kumbalangi, Kumbalam and Sattar Island, with further stands at Panangad, Thrippunithura, Nettoor, Panambukad, Mulavukadu, Kannamali and Chellanam. These mangroves comprise 11 true species, with the family Rhizophoraceae contributing the largest number. Mangrove species show clear preferences by tidal exposure, which is itself a useful thing for a guide to point out on a walk. Avicennia officinalis, Rhizophora mucronata and Acanthus ilicifolius are commonly found right along the shoreline and waterfront, where they take continuous tidal flooding in their stride. *Rhizophora apiculata, Bruguiera sexangula, Kandelia candel* and *Sonneratia caseolaris* prefer mid-tide levels within the estuary, while *Bruguiera gymnorrhiza, Bruguiera cylindrica* and *Acrostichum aureum* are more often found further landward, near human settlement; *Excoecaria agallocha*, meanwhile, prefers sandy saline soils. Recognising these preferences is useful for more than storytelling, it also guides effective monitoring and rejuvenation work, since restoration planting that respects natural species associations avoids setting up unnecessary competition between species.

In terms of sheer numbers, *Avicennia officinalis* is the most abundant species in the Vembanad system, accounting for about 35% of the total mangrove population, followed by *Acanthus ilicifolius* (20%) and *Rhizophora mucronata* (18%). Of these, *Acanthus ilicifolius* is IUCN-listed as Endangered and *Rhizophora mucronata* as Vulnerable — both worth flagging to guests as a reminder that 'common-looking' mangrove species are not automatically safe from concern.

A healthy patch of Rhizophora mucronata at Mulavukad

View of the mangrove patch at Puthuvypin

Reference Table: True Mangrove Species of the Vembanad Lake System

S.No.	Species	Family	Habit	Common Name	Local Name	Uses
1	*Acanthus ilicifolius*	Acanthaceae	Shrub	Sea Holly / Holly Mangrove	Chullikandal	Fuel wood
2	*Avicennia marina*	Acanthaceae	Tree	—	Cheruuppootti	Filtering of salt from saline water
3	*Avicennia officinalis*	Acanthaceae	Tree	White Mangrove	Uppotti	Filtering of salt from saline water; medicinal
4	*Bruguiera cylindrica*	Rhizophoraceae	Tree	Small-Leaved Orange Mangrove	Kuttikandal	Firewood, charcoal, fodder; tannin from bark
5	*Bruguiera gymnorrhiza*	Rhizophoraceae	Tree	Large-leafed Orange / Oriental Mangrove	Penakandal	Firewood, charcoal; tannin from bark
6	*Excoecaria agallocha*	Euphorbiaceae	Tree	Blind-Your-Eye Mangrove	Kannambotti	Medicinal

				/ Blinding Tree		
7	Kandelia candel	Rhizophoraceae	Shrub	Narrow-Leaved Kandelia	Cherukandal / Nallakandal	Medicinal
8	Rhizophora apiculata	Rhizophoraceae	Tree	Tall Stilted Mangrove	Vallikandal	Timber and construction ; medicinal
9	Rhizophora mucronata	Rhizophoraceae	Tree	Long-Fruited Stilted Mangrove	Peekandal / Pranthankandal	Timber and construction ; medicinal
10	Sonneratia alba	Lythraceae	Small Tree	Mangrove Apple	Kambetti / Nakshathrakandal / Appakkad	Food, timber and construction ; medicinal
11	Sonneratia caseolaris	Lythraceae	Small Tree	Apple Mangrove	Blathikandal / Chakkarakandal	Medicinal

Alongside the true mangroves, a wider community of salt-tolerant plants or the mangrove associates, shares this habitat. These are not confined to the intertidal zone in the way true mangroves are, but they are characteristic companions of the mangrove fringe and worth a mention if a guest's interest goes beyond the headline species. Reference Table: Mangrove Associates of the Vembanad Lake System

S.No.	Scientific Name	Vernacular Name (Malayalam)	Family	Habit	Common Name
1	*Acrostichum aureum*	Machithol, Chavithol, Thavikkad	Pteridaceae	Herb	Swamp fern / mangrove fern
2	*Annona glabra*	Kadalatha	Annonaceae	Tree	Pond apple
3	*Bacopa monnieri*	Brahmi	Plantaginaceae	Herb	Water hyssop
4	*Barringtonia racemosa*	Samudrachampa	Lecythidaceae	Tree	Powder-puff tree
5	*Cyperus rotundus*	Canita	Cyperaceae	Herb	Cyperus grass
6	*Dalbergia candenatensis*	Kulayeeti, Velleetti	Fabaceae	Climbing shrub	North Indian rosewood
7	*Derris scandens*	Ponnan valli	Fabaceae	Woody climber	Hog creeper

8	*Derris trifoliata*	Ponnuvalli	Fabaceae	Shrub	Three-leaf derris
9	*Diplachne fusca*	Chamappullu	Poaceae	Herb	Bearded sprangletop
10	*Dolichandrone spathacea*	Neerpongu	Bignoniaceae	Tree	Mangrove trumpet tree
11	*Fimbristylis ferruginea*	Puzhapotta	Cyperaceae	Herb	Rusty sedge / West Indian fimbry
12	*Fimbristylis polytrichoides*	Padappanpotta	Cyperaceae	Herb	Rusty sedge
13	*Hibiscus tiliaceus*	Thaliparuthi	Malvaceae	Shrub/Tree	Sea hibiscus / beach hibiscus
14	*Ipomea campanulata*	Manivalli / Adambu	Convolvulaceae	Large shrubby twiner	Bell flower morning glory
15	*Ipomea pescaprae*	Chuvanna adambu	Convolvulaceae	Creeper	Beach morning glory / goat's foot
16	*Cyperus javanicus*	Valeera	Cyperaceae	Sedge	Java sedge
17	*Morinda citrifolia*	Manjanathi	Rubiaceae	Tree	Noni
18	*Paspalum distichum*	Kulavarangu	Poaceae	Herb	Knot grass
19	*Phragmites karka*	Nannana	Poaceae	Herb	Tropical reed / tall reed
20	*Millettia pinnata*	Pongu	Fabaceae	Herb	Indian pongamia / karanja
21	*Premna serratifolia*	Kozhiyappa, Munja	Verbenaceae	Shrub/small tree	Indian headache tree
22	*Sauropus bacciformis*	Nilam-thengu	Euphorbiaceae	Herb	Creeping gooseberry
23	*Schoenoplectus littoralis*	Urunipotta	Cyperaceae	Herb	Coast clubrush
24	*Sesbania bispinosa*	Kilannu	Fabaceae	Shrub	Prickly sesban

25	*Sesuvium portulacastrum*	Smabar cheera	Aizoaceae	Herb	Sea purslane
26	*Sphenoclea zeylanica*	Pongathi	Sphenocleaceae	Herb	Gooseweed / crab's eye
27	*Terminalia catappa*	Thallithenga	Combretaceae	Tree	Indian almond tree
28	*Thespesia populnea*	Poovarasu, Cheelanthi	Malvaceae	Tree	Indian tulip tree
29	*Typha angustifolia*	Aanappullu	Typhaceae	Herb	Narrowleaf cattail / lesser bulrush
30	*Wedelia chinensis*	Manjakkayyonni	Asteraceae	Herb	Chinese wedelia / bhringraj
31	*Clerodendrum inerme*	Neernochi, Puzhamulla, Cheruchinna	Lamiaceae	Shrub	Glory bower / wild jasmine
32	*Crinum viviparum*	Polathali	Liliaceae	Bulbous geophyte	River crinum lily

3. Spotlight Series: Flagship Species / Case Studies

- **Kadalundi–Vallikkunnu Community Reserve**
  A 1.5 sq. km cluster of islands where the Kadalundi River meets the sea and one of Kerala's very best birding sites, all inside a community-managed mangrove reserve.
  - **Ecological Narrative:** About 100 km south of Kannur lies the Kadalundi–Vallikkunnu Community Reserve, an ecologically significant, community-managed estuarine reserve. It is highly regarded for its dense mangrove forests and rich bird diversity, with thick patches of salt-tolerant mangrove vegetation forming a complex mosaic of estuarine habitat, mudflats and sandbars. The reserve provides foraging ground for over 100 species of waterfowl, including dozens of migratory birds like terns, herons, gulls and sandpipers among them, that visit during winter. It is jointly managed by the Kerala Forest Department and the local community.
  - **For the Guide:** Visitors can explore its quiet waterways by non-motorised boat, with good chances of spotting otters and a range of other estuarine life, a genuine, low-impact wildlife experience rather than a manufactured attraction.

- **Rhizophora mucronata** *(the long-fruited stilted mangrove)*

  - **Ecological Narrative:** A tree-form true mangrove of the family Rhizophoraceae, known locally as Peekandal or Pranthankandal, valued for timber, construction and traditional medicine. It occupies the mid-tide levels of the estuary and is the third

most abundant species in the Vembanad system, at about 18% of the mangrove population.
    - **Conservation Status & Threats:** *Rhizophora mucronata* is IUCN-listed as Vulnerable, making it a useful species through which to introduce guests to the idea that even a locally common mangrove can carry a global conservation concern.

- **Avicennia officinalis** *(the white mangrove)*

    - **Ecological Narrative:** Known locally as Uppotti, this Acanthaceae-family tree is prized for its role in filtering salt from saline water and for traditional medicinal use. It is commonly found right along the shoreline and waterfront, tolerating continuous tidal flooding.
    - **Conservation Status & Threats:** Not currently IUCN-listed as threatened, but its dominance makes it the natural 'default' mangrove to teach identification from, before moving on to rarer species.

4. Practical Toolkit for the Field

Where and When to Look

The two flagship sites for guests are the Kadalundi–Vallikkunnu Community Reserve near Kannur, and the mangrove patches fringing Vembanad Lake, particularly Mangalavanam, Kumbalangi, Mulavukad and Puthuvypin. Both can be visited year-round, though calm, low-wind conditions make for easier boat access and better birding.

Reading the Environment

Position on the tidal gradient is the single most useful field cue: species right at the waterfront differ from those at mid-tide and from those further landward. Pointing out this zonation rather than naming species at random gives guests a genuine framework for what they are looking at.

Field Etiquette & Responsible Code of Conduct

- Keep to boardwalks, marked paths or boats; avoid trampling pneumatophores (breathing roots) and seedlings.
- Do not collect leaves, bark, seed pods or wildlife from the reserve.
- Prefer non-motorised or low-noise boats in mangrove channels, especially around nesting or roosting birds.
- Respect the joint management arrangements of community reserves such as Kadalundi-Vallikkunnu follow local guides' and Forest Department instructions.

Managing Expectations

Mangrove patches in Kerala are now fragmented and under real pressure, so guests should not expect the extensive, continuous mangrove forest they may have seen elsewhere in South or Southeast Asia. Bird sightings at Kadalundi are seasonal and strongest in winter, when migratory species are present.

5. Quick-Reference Summary Table

A one-glance guide to Kerala's mangrove ecosystem for field use.

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Vembanad Lake mangroves	Avicennia officinalis, Rhizophora mucronata	Visit Mangalavanam, Kumbalangi, Mulavukad or Puthuvypin	About 600 hectares of mangrove cover across 11 true species
Kadalundi-Vallikkunnu Reserve	Migratory waterfowl, terns, herons, otters	Explore by non-motorised boat, best in winter	Community-managed reserve with over 100 waterfowl species
Coastal bio-shield function	Dense stilt and pneumatophore root systems	Point out roots as wave- and surge-breakers	Mangroves reduce wave energy and slow storm surges
Blue carbon storage	Waterlogged mangrove soils	Explain mangroves as climate-mitigation infrastructure, not just scenery	Mangroves store carbon in biomass and soil for the long term
Conservation status	Acanthus ilicifolius (Endangered), Rhizophora mucronata (Vulnerable)	Flag IUCN status when naming these species	Kerala's mangrove cover is shrinking under development pressure

6. Chapter Glossary

- **Halophyte:** a plant adapted to grow in salty soil or water; mangroves are facultative halophytes, tolerating salt without requiring it.
- **Intertidal zone:** the shore area exposed at low tide and submerged at high tide.
- **Blue carbon:** carbon captured and stored by coastal and marine ecosystems such as mangroves, seagrasses and salt marshes.
- **True mangrove vs mangrove associate:** true mangroves are specially adapted to live within the intertidal zone itself; associates are salt-tolerant plants found around the mangrove fringe but not restricted to it.
- **Bio-shield:** a living, vegetated buffer, here the mangrove belt, that absorbs wave energy and storm surge to protect the coast behind it.
- **Zonation:** the pattern by which different mangrove species dominate different positions across the tidal gradient, from waterfront to landward edge

7. Sources and Further Reading

- Forest Survey of India - national mangrove cover assessments.
- Kerala Forest Department - joint management of the Kadalundi–Vallikkunnu Community Reserve.
- IUCN Red List - conservation status of mangrove species (Acanthus ilicifolius, Rhizophora mucronata and others).

CHAPTER 8

CAGE AND POND CULTURE IN KERALA

Farming Fish in the Backwaters, Reservoirs and the Sea

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> ***How to Use This Chapter:*** *Along Kerala's backwaters, reservoirs and sheltered coast, fish are increasingly farmed in floating net enclosures and in ponds. This chapter explains how cage and pond culture works, where to see it, what is cultured (including the famous Karimeen), and how a guide can turn a floating fish farm into a memorable, responsible stop.*

In This Chapter

1. Introduction & Coastal Context

Cage culture is an aquaculture system in which fish and other aquatic animals are reared inside enclosed net pens installed in natural water bodies like estuaries, backwaters, lakes, reservoirs, and coastal or offshore sea. The system permits free flow of water through the cage while securely confining the stock. In effect, it is farming fish without owning any land, the water body is borrowed, and only the pen is built. It is one of the newer branches of aquaculture, and an efficient, comparatively low-footprint way to raise fish. Globally, cage systems range from small, family-run units common across Asia to highly mechanised, large-scale commercial operations such as the salmon and trout farms of northern Europe and the Americas. In India, cage farming has grown quickly over the past decade, spreading from sheltered coastal bays to offshore waters and inland reservoirs, boosting fish production while opening new livelihoods for coastal and rural communities.

Global mariculture (marine farming, including seaweeds) now exceeds 54 million tonnes and contributes more than half of the world's aquaculture output. India's marine capture fisheries, by contrast, have plateaued at around 3.5 million tonnes a year, so simply catching more wild fish is neither economically nor ecologically sustainable. India's total fish production has climbed steeply, to roughly 19 million tonnes in 2024–25, about double the 2013–14 figure, yet demand keeps rising. With capture stagnant and limited room to expand inland pond farming, mariculture is widely seen as the main frontier for sustainable growth, and marine cage farming is central to it: it can raise high-value fish in coastal and offshore waters while easing pressure on wild stocks and creating coastal jobs.

India is well endowed for mariculture: a long coastline (officially re-estimated at 11,098.81 km in 2024), a territorial sea of about 193,834 km², and a large marine fishing community across nine maritime states and 66 coastal districts, supported by major and minor fishing harbours and more than 1,500 fish-landing centres. Extensive shallow inshore waters, and sheltered spots such as bays, lagoons, estuaries and protected coastal areas, are especially suited to cage farming. Among the maritime states, Kerala is particularly well placed: it has more than 46,000 hectares of backwaters, numerous estuaries and brackish-water systems, and several large freshwater reservoirs that provide ideal sites for cage farming. High-value species such as Pearl Spot (Etroplus suratensis), Asian Seabass (Lates calcarifer), Red Snapper (Lutjanus spp.) and Tilapia (Oreochromis spp.) all grow well under Kerala's conditions.

2. Core Concepts & Environmental Dynamics

Where Cage Culture Happens in Kerala

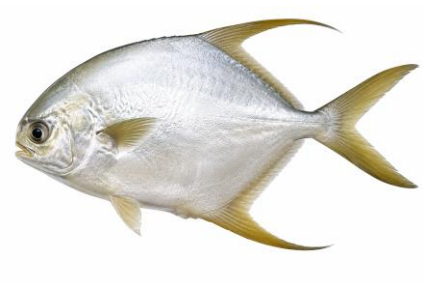
Several regions are recommended for cage culture, based on successful operations and local hydrology:

- Ernakulam: the main hub for cage farming in the state, with established clusters in Vembanad Lake and the Periyar delta.
- Thiruvananthapuram: concentrated in the Neyyar Dam reservoir, which has earned wide attention for its community-based aquaculture projects.
- Kollam: in the district's wide estuarine and backwater network, notably Ashtamudi Lake and the Kayamkulam backwater, with active units around Munroethuruthu and Sakthikulangara.
- Alappuzha: around the brackish waters of Vembanad Lake, Kuttanad and the coastal belt; the Alleppey Fish Farm at Valiyaparambu is a well-known local provider.
- Thrissur: in the coastal and brackish belts around Puthenvelikkara, Kodungallur, Gothuruthu and Chavakkad.
- Malappuram: in the brackish estuaries and backwaters near Ponnani and Parappanangadi.
- Malabar (Kannur, Kozhikode, Kasaragod): the Korapuzha estuary, the Kavvayi backwaters and the Anjarakandy River are good brackish-water cage sites.
- Reservoirs: freshwater cage culture runs in Banasura Sagar and Karapuzha (Wayanad), Peruvannamuzhi (Kozhikode) and Kakki (Pathanamthitta).

What is Farmed

Fast-growing, high-value species give the best returns. The choice depends on the water: brackish and estuarine waters favour Pearl Spot (Karimeen), Asian Seabass, Red Snapper, Giant Trevally and mullet; freshwater reservoirs and ponds favour Indian major carps and exotic carps, improved Tilapia (GIFT) and Pangasius, alongside indigenous species such as Climbing Perch (Kaithakkora); and marine sea cages favour Cobia, Silver Pompano, snappers, groupers and spiny lobster.

Red Snapper



Silver Pompano

Sea Bass

Cobia

Sea Cage Farming

Sea cage farming is among the most promising ways to raise seafood production, and has expanded rapidly worldwide. India is still at an early stage: an estimated 2,500 cages in inshore and brackish waters produce roughly 2,500 tonnes of fish a year. The scope is enormous. ICAR–CMFRI projects that using just 1% of India's suitable inshore waters could hold about 820,000 cages producing some 3.2 million tonnes of fish. Sea cage farming in India was pioneered by ICAR–CMFRI in 2005, with the Ministry of Agriculture & Farmers' Welfare and the National Fisheries Development Board (NFDB), and has since spread along the Indian coast.

Stages of cage fabrication

A circular cage of at least 6 m diameter and 4 m depth (about 113 m^3), or a rectangular cage of 4 × 4 × 4 m (about 64 m^3), is typical. Each cage is ringed by a predator net with a one-metre gap all round, and a bird net is laid over the frame. A fishers' group, cooperative, self-help group or entrepreneur may install up to 20 cages at one site, forming a cage-farming cluster that shares infrastructure and cuts costs. Stocking density is set to a production target of about 25–30 kg per m^3. Biofouling, algae and organisms clogging the mesh, is managed by regular net brushing, and harvesting is staggered to market demand, taking larger fish first to avoid gluts.

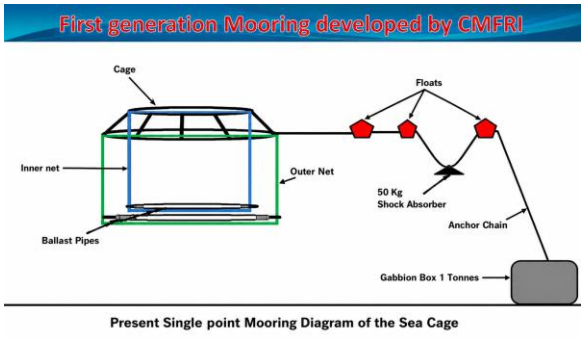
Cage Culture in Inland Open Waters

India has about 3.15 million hectares of reservoirs and some 0.8 million hectares of floodplain wetlands. Yields from these are far below their potential: reservoirs average only around 82 kg/ha against a potential of 100–500 kg/ha. Enclosure culture such as cages and pens can help close that gap. A fixed cage suits shallow water (1–3 m) with the net bag fixed to posts; a floating cage suits water deeper than about 5 m, hung from a floating frame so it clears the bottom. Inland aquaculture is dominated by the three Indian major carps, Catla, Rohu and Mrigal, alongside tilapia and pangasius.

Building and Siting a Cage

Site selection is the single most important decision. Key factors include depth (enough to keep nets clear of sediment), water exchange, tidal amplitude (ideally about 1-1.5 m or less), wave action, wind velocity (below about 30 km/h), water quality, bottom type (sandy or rocky preferred over muddy) and freedom from pollution. Cages are typically built from galvanised-iron (GI) frames, square, rectangular or round, sized to the water body, welded and coated

with marine epoxy, fitted with at least eight 500-litre plastic drums per cage for buoyancy, and covered by an HDPE predator net, an inner grow-out net and a bird net. Mooring is single (swinging 360°) in the sea, or double (poles in shallow water, anchors in deeper water) in tidal lakes, rivers and backwaters.



Cage deployed in a backwater

Fish Farming in Ponds

Ponds remain the backbone of Indian aquaculture. Freshwater ponds commonly raise carps, tilapia, catfish, snakehead, gourami and the giant freshwater prawn (Macrobrachium). Brackish-water ponds raise Pearl Spot, mullet, milkfish and penaeid shrimps. Two fishes anchor India's traditional and scientific pond culture: the striped grey mullet (Mugil cephalus) and milkfish (*Chanos chanos*). The mullet tolerates a wide range of water conditions, mixes well with other species, grows fast and commands strong market prices. Typical water-quality targets for mullet ponds are as follows:

Parameter	Target range
Salinity	15–35 ppt
pH	6.5–9.0
Dissolved oxygen	4–5 mg/L
Nitrate	0.1–4.5 mg/L
Nitrite	< 0.5 mg/L
Ammonia (total)	< 0.1 mg/L
Phosphate (available)	0.1–0.5 mg/L
Plankton	good productivity

Ponds are prepared by drying, ploughing and manuring with 2.5–5.0 t/ha of cow dung, then filled to 25–30 cm and left 7–10 days for natural feed to build up. Most grey-mullet fry are still collected from the wild: nursery ponds (about 1–10% of the total area, 15–25 cm deep) receive fingerlings of 10–15 g, and mullet reach market size of 0.75–1.0 kg in 7–8 months. Milkfish is a hardy, warm-water (20–33°C), largely herbivorous fish that grows well in fresh, brackish and marine ponds; nursery ponds are dried, limed and fertilised to grow the benthic

algal mat known as lab-lab, with fry stocked at 30–40 per m² for 30–45 days before grow-out.

Getting started: ICAR–CMFRI generally recommends galvanised-iron (GI) or high-density polyethylene (HDPE) cages, typically about 4 × 4 × 3 m. A small-scale cage unit starts from roughly ₹60,000 upwards, and a standard 113 m³ circular cage can yield up to about 2.4 tonnes of fish, with inputs of around ₹5 lakh reportedly returning net profits of about ₹2.2 lakh. ICAR–CMFRI (Kochi) and the Agency for Development of Aquaculture, Kerala (ADAK) provide technical support, cage-fabrication guidance, site selection and regular capacity-building programmes for local entrepreneurs.

3. Spotlight Series: Flagship Species / Case Studies

- **Pearl Spot** *(Etroplus suratensis, "Karimeen")*
    - **Farming Narrative:** Pearl Spot thrives in brackish backwater cages and ponds across Vembanad, Ashtamudi and Kayamkulam, and is one of the flagship species recommended for Kerala's cage-culture clusters. Much of what visitors eat today as Karimeen is now farmed in these very cages and ponds.
    - **Status & Considerations:** A resilient, well-established farmed species with no significant conservation concern; the challenge is one of sustainable expansion and market supply rather than wild population pressure.

- **Milkfish** *(Chanos chanos)*
    - **Farming Narrative:** Milkfish is a warm-water (20–33°C), largely herbivorous fish, grazing on cyanobacteria, diatoms, soft algae and small invertebrates, that grows well in monoculture or polyculture across fresh, brackish and marine ponds. Hatchery and grow-out technology is established in India through ICAR–CIBA. Wild fry migrate inland to tidal pools before moving to lagoons and shallows, though intensive farming now relies on hatchery fry.
    - **Status & Considerations:** Disease-resilient and one of the cheapest sources of animal protein in the region; not a conservation concern, and a strong candidate for expanding Kerala's brackish-water pond culture.

- **Cobia and Silver Pompano** *(Rachycentron canadum & Trachinotus blochii)*
    - **Farming Narrative:** Along with groupers and Asian Seabass, Cobia and Silver Pompano are the flagship species of India's sea-cage farming programme, pioneered by ICAR–CMFRI in 2005. Rising demand for quality seed drove hatchery technology for these high-value finfish, making them popular with fishers' groups and aquaculture entrepreneurs nationwide. They are typically stocked in circular sea cages at a production target of about 25–30 kg per m³.
    - **Status & Considerations:** Both species are farmed, not wild-caught for this trade, so the conservation story here is one of easing pressure on wild fish stocks by substituting farmed high-value fish for capture fishery effort.

4. Practical Toolkit for the Field

Where and When to Look

A cluster of floating cages with their feeding platforms on the calm backwaters of Vembanad, Ashtamudi or Kayamkulam, or on a reservoir like Neyyar, is photogenic and fascinating at feeding or harvest time.

Reading the Environment

The community-run cage farms at Neyyar Dam are a genuine livelihoods success worth telling as a story; and the Karimeen on the dinner plate links the farm directly to the famous cuisine, making fish farming a natural extension of a food-and-culture conversation rather than a purely technical stop.

Field Etiquette & Responsible Code of Conduct

- Ask the farmer's permission first; keep your group quiet and unhurried.
- Watch feeding from a respectful distance, and where offered, buy fish directly to support the farmers.
- Do not lean on or disturb the cages, floats or nets; do not feed the fish.
- Do not drop litter or pollute the water, and do not photograph people without their consent.

Managing Expectations

These are working farms, not attractions, access varies and is never guaranteed. Arrange visits through local contacts, and ADAK or ICAR–CMFRI can advise on demonstration sites. Fish farming is not an obvious 'sight', but handled well it makes a fresh, authentic stop that most visitors have never seen, and a genuine window into coastal livelihoods.

5. Quick-Reference Summary Table

A one-glance guide to the culture systems, where they occur, and what they grow.

Culture system	Where in Kerala	Key species	Typical setup	Good to know
Brackish-water cages	Vembanad, Ashtamudi, Kayamkulam & estuaries	Pearl spot (Karimeen), Asian seabass, red snapper, mullet	HDPE/GI cages, ~4×4×3 m	The commonest type; clustered near backwater villages.
Sea (marine) cages	Sheltered coastal bays; increasingly offshore	Cobia, silver pompano, groupers, seabass, lobster	Circular HDPE, 6 m dia × 4 m (≈113 m^3); up to 20/cluster	High-value; needs calm, deeper water.
Reservoir / freshwater cages	Banasura Sagar, Karapuzha, Peruvannamuzhi, Neyyar, Kakki	GIFT tilapia, carps, pangasius	Floating cages, 1–500 m^2	Neyyar is a noted community-run project.

Brackish-water ponds	Coastal belts, Kuttanad	Pearl spot, mullet, milkfish, shrimp	Earthen ponds	Both traditional and scientific culture.
Freshwater ponds	Across the state	Carps, GIFT tilapia, catfish, giant freshwater prawn	Earthen ponds	India's aquaculture mainstay.

6. Chapter Glossary

- **Mariculture:** the farming of marine organisms in the sea or in seawater.
- **Cage / pen culture:** growing fish in a net enclosure set within a natural water body.
- **HDPE / GI:** high-density polyethylene and galvanised iron, the common cage-building materials.
- **Mooring:** the anchors, chains and lines that hold a cage in place.
- **Biofouling:** the build-up of algae and organisms that clogs cage nets and must be brushed off.
- **Fry / fingerling:** successive young stages of a fish; fingerlings are the size usually stocked.
- **Stocking density:** how many fish (or what biomass) are placed per unit of water.
- **Monoculture / polyculture:** growing one species, or several complementary species together.
- **Grow-out / nursery:** the phase of raising stock to market size, and the earlier phase of raising tiny young.
- **Predator net / bird net:** outer and overhead nets that keep predators and birds away from the stock.
- **Lab-lab:** a natural mat of benthic algae and organisms grown in ponds as fish food.
- **Brackish water:** the mix of fresh and salt water found in estuaries and backwaters.

7. Sources and Further Reading

- ICAR–Central Marine Fisheries Research Institute (CMFRI), Kochi (cmfri.org.in) -marine cage-farming research, technology and the CMFRI Sea Cage Farming Training Manual (Training Manual Series, 2025).
- Agency for Development of Aquaculture, Kerala (ADAK) - technical support, training and site guidance.
- National Fisheries Development Board (NFDB) and the Ministry of Fisheries, Animal Husbandry & Dairying - national programmes and statistics.
- ICAR–Central Institute of Brackishwater Aquaculture (CIBA) - brackish-water species and hatchery technology.
- Selected references: Jha et al. (2013) on reservoir yields; Sugunan & Sinha (2001) on floodplain wetlands.

Note: national production, price and investment figures shift year to year; refresh them from the latest CMFRI and Department of Fisheries data at each edition.

CHAPTER 9

SEAFOOD EXPORTS FROM INDIA

Challenges and Opportunities in a Growing Global Trade

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> ***How to Use This Chapter:*** *Guests on a coastal or backwater tour often ask what happens to the catch after it leaves the boat. This chapter gives you the bigger picture: where India and Kerala stand as seafood exporters, the government policies and research effort behind the industry, the international standards and disputes exporters must navigate, and where the sector is headed next.*

In This Chapter

1. Introduction & Coastal Context

India is one of the world's leading producers of fish and fishery products. The fisheries sector plays an important role in the country's economy by providing food, nutrition, employment, livelihood and foreign exchange earnings. Besides meeting domestic demand, India exports a wide variety of seafood products to countries across the world, an income stream that matters to fishers, farmers, processors and exporters alike, and to the national economy behind them.

In recent years, India's seafood exports have grown remarkably despite global headwinds such as trade restrictions, shifting consumer preferences and rising quality standards. For anyone guiding visitors through a fishing harbour, a processing plant, or a backwater aquaculture farm, understanding this bigger picture - status, opportunity and challenge alike - turns a simple boat-watching stop into a much richer conversation.

2. Core Concepts & Environmental Dynamics

Present Status of Seafood Exports

India currently ranks sixth globally among seafood-exporting countries. During 2024–25, it exported about 1.69 million tonnes of seafood worth approximately ₹62,408 crore (US$7.45 billion). Seafood exports alone account for nearly 18% of India's agricultural and allied exports. India exports a wide range of products from frozen shrimp, frozen finfish, cuttlefish, squid, live fish, chilled fish and dried fish. Frozen shrimp alone is by far the most valuable of these, contributing nearly 70% of total export earnings.

Both marine capture fisheries and aquaculture contribute to India's seafood exports, but in different ways. Marine capture fisheries account for about half of the export quantity, but a smaller share of value, since many wild-caught species command lower market prices than cultured shrimp. Aquaculture, above all, shrimp farming, is the real driver of export earnings: it generates nearly 60% of export value from a smaller share of quantity, and farmed shrimp alone accounts for almost 80% of India's shrimp exports. That gap is a useful figure to have on hand. It shows just how far scientific aquaculture has outpaced the traditional catch in driving India's export income.

Seafood Export Sector in Kerala

Kerala has historically been one of India's leading seafood-exporting states, and played a pioneering role in building the country's marine products export industry. With a coastline of about 590 km, an extensive network of backwaters and rich marine fishery resources, the state has long been recognised for the harvest, processing and export of high-quality seafood. Kochi is Kerala's major seafood export hub, home to a large number of export-oriented processing plants, cold storage facilities, ice plants and logistics infrastructure. It is also headquarters to the Marine Products Export Development Authority (MPEDA) and to premier fisheries research institutions, including ICAR–CMFRI and ICAR–Central Institute of Fisheries Technology (CIFT), making Kochi as much a centre for fisheries research, technology and quality assurance as it is a trading port.

Kerala exports shrimp, cephalopods (squid and cuttlefish), finfish, ribbonfish, seer fish, tuna, sardines, mackerel and value-added products. While shrimp contributes significantly to earnings, Kerala is particularly known for marine capture fishery exports, especially cephalopods and high-value finfish. The sector generates substantial foreign exchange and direct and indirect employment across fishing, aquaculture, peeling sheds, processing plants, ice factories, cold-chain operations, packaging, transport, port handling, quality testing and export logistics with a large share of this workforce, particularly in processing and value addition, being women.

Government Policies Supporting Seafood Exports

The Government of India has introduced several policy measures to strengthen seafood exports, with the focus gradually shifting from protecting only consumers towards improving the income and welfare of farmers and fishers themselves. Greater emphasis is now placed on value addition under the 'Make in India' initiative, so that more processed and branded seafood rather than raw material leaves the country. The government also monitors domestic production and supply to balance food security at home with export demand, and works to improve coordination among the many departments and institutions involved in

fisheries development. At the international level, India is actively exploring new Free Trade Agreements (FTAs) and bilateral trade agreements to widen market access, while strengthening quality control, certification systems and export inspection mechanisms remains a continuing priority.

Role of Research and Innovation

Research and technological innovation are central to India's competitiveness in international seafood markets. Better aquaculture technology is essential to meet growing global demand, and improved shrimp-farming methods can help Indian producers compete more effectively with major rivals such as Ecuador. There is also real potential to grow exports of tuna and other high-value marine species, something that depends on better onboard handling, modern storage, improved processing, skilled fishing crews and internationally recognised sustainability certification.

Value addition is another key frontier: only a small share of India's seafood exports are currently highly processed products such as ready-to-cook or ready-to-eat items. Developing modern processing technology, better cold-chain infrastructure, innovative packaging and diversified products can substantially increase export earnings. Research institutions also support exporters directly, through food-safety testing, quality assurance, intellectual property protection, and technical guidance for start-ups and small entrepreneurs in fisheries and seafood processing.

3. Spotlight Series: Flagship Species / Case Studies

- **Government of India's Response** *(the U.S. Marine Mammal Protection Act (MMPA)*
    - **The Story:** The United States is one of the largest markets for Indian seafood, particularly frozen shrimp. Under the U.S. Marine Mammal Protection Act (MMPA), exporting countries must demonstrate that their fisheries maintain bycatch-prevention standards comparable to those of the United States when it comes to the incidental capture of marine mammals during fishing. To meet this requirement, the Government of India, through MPEDA, the Department of Fisheries, and ICAR–CMFRI, undertook extensive scientific studies and data collection to prepare and submit a Comparability Finding Application (CFA) to U.S. authorities. CMFRI's role was central: generating scientific evidence on interactions between marine mammals and Indian fisheries, assessing bycatch risk, and documenting responsible fishing practice.
    - **Outcome:** The successful CFA submission demonstrated India's commitment to sustainable fisheries management and helped secure continued access to the U.S. market — a clear example of research directly protecting an export livelihood.
- **Turtle Excluder Devices** *((TEDs) in trawl fisheries)*
    - **The Story:** Sea turtles are a protected species that can occasionally become entangled in shrimp trawl nets. A Turtle Excluder Device (TED) is a specially designed grid fitted inside a trawl net that lets shrimp and fish pass through into the cod end, while directing larger animals such as turtles safely out through an escape

opening. Recognising both the conservation stakes and the international market requirement, the Government of India has promoted TED installation and use in shrimp trawl fisheries through awareness programmes, demonstration trials, fisher training, and collaborative research involving MPEDA, CMFRI, CIFT, State Fisheries Departments and other stakeholders.

- **Outcome:** TED adoption serves two purposes at once: protecting endangered sea turtles, and strengthening India's compliance with the international standards its export markets require.

- **Sustainability Certification and Traceability**

  - **The Story:** Global consumers are increasingly conscious of sustainability, and many buyers now look for internationally recognised eco-certification on the seafood they buy. Alongside this, mandatory traceability systems require complete, verifiable information on the origin, harvesting, processing and transport of a product across the entire supply chain, turning what was once a simple export shipment into a fully documented journey from net to plate.
  - **Why It Matters:** Meeting these standards is now a competitive necessity rather than an optional extra for Indian exporters, alongside continuing pressure from non-tariff barriers such as sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT), and growing competition from other seafood-exporting nations.

4. Practical Toolkit for the Field

Where and When to Look

Kochi's fishing harbour, processing plants and cold-storage facilities are the most visible face of the export trade; landing centres elsewhere along the coast show the capture side of the chain, while backwater cage and pond farms (see Chapter 8) show the aquaculture side that now drives most export value.

Reading the Environment

Frozen shrimp is by far the single most valuable export product, so a shrimp pond or hatchery a guest sees on a backwater tour is very plausibly linked, directly or indirectly, to the export trade rather than only to the local plate.

Field Etiquette & Responsible Code of Conduct

- Processing plants, cold storages and export facilities are working biosecurity-sensitive sites, not visitor attractions. Never enter or photograph without explicit permission.
- At landing centres and harbours, keep clear of active loading and unloading, and avoid handling catch or gear without invitation.

Managing Expectations

Public access to export processing infrastructure is limited and rarely guaranteed. This is best treated as background knowledge that enriches a harbour or backwater visit, rather than as a stop in its own right.

5. Quick-Reference Summary Table

India's seafood export sector at a glance (2024–25 figures).

Indicator	Figure (2024–25)
Global export rank	6th
Export volume	~1.69 million tonnes
Export value	₹62,408 crore (US$7.45 billion)
Share of India's agricultural exports	~18%
Leading export commodity	Frozen shrimp (~70% of export earnings)
Major destinations	United States, China, European Union, Japan, Middle East

6. Chapter Glossary

- **MPEDA:** Marine Products Export Development Authority, headquartered in Kochi, the apex body promoting India's seafood exports.
- **CIFT:** ICAR–Central Institute of Fisheries Technology, Kochi - works on fishing technology, processing and quality.
- **CFA:** Comparability Finding Application - India's submission proving its fisheries meet U.S. bycatch-prevention standards under the MMPA.
- **MMPA:** the U.S. Marine Mammal Protection Act, which requires exporting countries to show bycatch standards comparable to U.S. fisheries.
- **TED:** Turtle Excluder Device - a grid fitted in a trawl net that lets shrimp through while releasing turtles and other large animals unharmed.
- **SPS / TBT:** Sanitary and Phytosanitary measures / Technical Barriers to Trade - non-tariff regulatory requirements that exporters must meet.
- **Traceability:** the ability to track a seafood product's origin, harvesting, processing and transport across the full supply chain.
- **FTA:** Free Trade Agreement - a bilateral or multilateral pact reducing trade barriers between countries.

7. Sources and Further Reading

- Marine Products Export Development Authority (MPEDA), Kochi - export statistics and policy.
- ICAR–Central Institute of Fisheries Technology (CIFT), Kochi - fishing technology, processing and quality standards.
- Ministry of Fisheries, Animal Husbandry & Dairying, Government of India - national fisheries and export policy.
- U.S. Marine Mammal Protection Act (MMPA) documentation and India's Comparability Finding Application (CFA).

Note: export volumes, values and market shares change year to year; refresh from the latest MPEDA and Ministry data at each edition.

CHAPTER 10

RESPONSIBLE AND ECO-FRIENDLY TOURISM

Travelling — and Guiding — in a Way That Leaves Kerala Better

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> ***How to Use This Chapter:*** *Tourism touches many other trades like hospitality, transport, food, crafts. Handled carelessly it damages the very places people come to see; handled responsibly it protects them and spreads the benefit locally. This chapter explains responsible and eco-friendly tourism, Kerala's pioneering Responsible Tourism Mission, and the concrete things a guide can do, especially on our fragile coasts and reefs, to leave a destination better for both those who live there and those who visit.*

In This Chapter

1. Introduction & Coastal Context

The tourism industry has many strengths, and it is connected to and supported by many others like hospitality and accommodation, transport, food and beverage, and tour operators and travel agencies. So responsible, eco-friendly tourism concerns all of them. We live in an age of rising environmental awareness, facing a host of challenges from both natural and human causes, and it is human activity that most alters natural systems. The human element in tourism is exactly why we must travel responsibly. People travel for many reasons - leisure, study, research, medical care. But whatever the reason, every traveller should travel responsibly. This chapter explains why, and how, on the coasts and backwaters a guide is most likely to be working.

2. Core Concepts & Environmental Dynamics

What is Responsible Tourism?

Responsible Tourism (RT) in Kerala rests on three linked responsibilities: economic, social and environmental, known as its triple bottom line. It covers all forms of tourism and seeks to minimise the negative economic, environmental and social impacts of travel while maximising the good. It brings greater economic benefit to local people, enhances the wellbeing of communities, and contributes to conserving natural and cultural heritage and the world's diversity — respecting nature, culture, food and the environment alike. The idea is simple: does every rupee a visitor spends help make the destination a better place both to live in and to visit? Kerala answers that across three responsibilities: economic (local sourcing, village jobs, keeping the tourism rupee within the community, often routed through Kudumbashree groups), social (women-led units, safe and gender-inclusive destinations, protecting local culture, fair working conditions) and environmental (waste management, a ban on single-use plastic, protecting water bodies and backwaters, conserving forests and wildlife, favouring low-impact experiences).

Kerala's Responsible Tourism Mission

Tourism contributes roughly 10% of Kerala's economy, and several local strengths made the state well placed to adopt and enforce Responsible Tourism. The Responsible Tourism Mission launched by the Government of Kerala in 2017 is the state's nodal agency for spreading and implementing RT ideas, activities and initiatives, and is also the State Nodal Agency for the Union Ministry of Tourism's Rural Tourism Development Project. Kerala's RT work has been recognised repeatedly by the world's leading tourism bodies like UN Tourism, PATA and World Travel Market, over more than a decade, making it a globally decorated model. The Mission has designated many RT destinations, including Kumarakom, Aymanam and Vaikom (Kottayam), Vythiri and Ambalavayal (Wayanad), Thekkady (Idukki), Kovalam and Madavoorpara (Thiruvananthapuram), Bekal (Kasaragod), Ponnani (Malappuram), and sites in Kannur and Kozhikode, with newer additions including Dharmadam, Varkala, Poovar, Ashtamudi, Alappuzha, Muhamma and Fort Kochi.

Eco-Friendly Tourism

Eco-friendly tourism means conserving the environment by protecting the fragile ecosystems that tourism draws on, and that are sometimes over-exploited. It is driven by minimising environmental impact and footprint, conserving wildlife and indigenous economies, and

committing to choices that do least harm to local communities and ecosystems. Its benefits fall into the same three familiar categories: environmental (habitat preservation, reduced waste and carbon emissions, support for conservation), economic (entrepreneurship, jobs, infrastructure investment) and social (respect for indigenous cultures, support for local artisans, authentic cultural exchange). Sustainability is the thread running through all of it, a harmonious relationship between travellers and local ecosystems, with the stakes highest for a coastal guide.

3. Spotlight Series: Flagship Species / Case Studies

- **Blue Flag Beaches**
  - **The Story:** The Blue Flag is a global eco-label awarded by the Denmark-based Foundation for Environmental Education (FEE) to beaches that meet 33 stringent criteria across environmental education, water quality, environmental management, and safety and services including proper waste bins, recycling and strict anti-dumping rules. As of 2025, India has 13 Blue Flag beaches, and Kerala has two, Kappad (Kozhikode) and Chal (Kannur), added in January 2025, the most of any Indian state at the time. These beaches are maintained with eco-friendly cleaning that preserves natural debris and habitats.
  - **Threats & Responses:** Beach litter more broadly remains a serious threat. Plastics, discarded fishing gear and tourism debris badly degrade coastal ecosystems and are often a symptom of overcrowding or a sanitation failure. Plogging (picking up litter while jogging) and organised clean-up drives are simple, effective responses.

- **Marine Trophy Hunting and the Illegal Wildlife Trade**

  - **The Story:** Despite laws against it, ocean animals are still hunted for sport and for trophy parts, a trade driven by traditional medicine, luxury, decoration and exotic demand. Sea cucumbers are heavily harvested along the Indian coast (including the Gulf of Mannar and Lakshadweep) for illegal export to East and South-East Asia, though they are vital sediment recyclers whose removal lets organic waste smother the seafloor. Hawksbill turtles are poached for their shells and Green turtles for meat and curios; seahorses and rays are traded for traditional medicine and the aquarium trade; and protected seashells and gastropods are over-exploited for the illegal curio trade.
  - **Legal Status & Guiding Response:** Many fishes, molluscs, reptiles, birds, sponges, sea cucumbers, corals and sea anemones are listed on Schedules I and II of the Wild Life (Protection) Act, with strict penalties for harming or trading in them, alongside international protection under CITES and the Convention on Migratory Species (CMS). Awareness is a powerful safeguard against well-meaning tourists making costly mistakes.

- **Coral Reef Damage from Tourism**

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  - **The Story:** Coral reefs are often considered even richer in biodiversity than rainforests which makes irresponsible reef tourism especially costly. When a boat anchors on a reef, the heavy metal anchor and chain crush living coral heads and leave permanent scars. Tourists who touch or stand on corals break the fragile

branches, strip away the protective mucus layer and introduce pathogens that can kill whole colonies, while nearby hotels, resorts and infrastructure add habitat loss, sediment and pollution that blocks the sunlight corals need.

- **Threats & Responses:** Though tourism can fund reef protection, it also harms reefs directly. the guiding response is simple and firm: use mooring buoys, never anchor on a reef, and look but never touch or stand on coral.

4. Practical Toolkit for the Field

Where and When to Look

RT-designated destinations and Blue Flag beaches are the natural places to steer visitors towards, since they are built and certified around the responsibilities this chapter describes.

Reading the Environment

Driving vehicles on beaches is a serious and easily overlooked threat: the weight compacts the sand, disrupts burrowing animals and plants, alters topography, increases erosion and directly threatens nesting sea turtles, shorebirds and their well-camouflaged eggs. It may look harmless, but its cumulative effects cause long-term ecological damage.

Field Etiquette & Responsible Code of Conduct

- Champion the local economy: favour local transport, food, homestays and artisans, and Kudumbashree units; keep the tourism rupee in the community.
- Respect people and culture: honour local customs, dress and rituals; ask permission before photographing people; promote authentic art forms.
- Keep beaches and water clean: carry out all litter, refuse single-use plastic, and join or organise plogging and clean-up drives.
- Protect reefs and marine life: never anchor on coral- use mooring buoys; look but don't touch or stand on coral; keep a respectful snorkelling distance.
- Never buy or collect wildlife products: no shells, corals, turtle products, seahorses or sea cucumbers. It is illegal under the Wild Life (Protection) Act and CITES, and drives species to collapse.
- Tread lightly on fragile coasts: keep vehicles off beaches; stay on paths; steer clear of turtle nests and shorebird roosts; never feed feral dogs or wild animals, and secure food waste.
- Choose responsible destinations: favour RT-designated sites and Blue Flag beaches, and low-impact, nature-based experiences; respect Coastal Regulation Zone (CRZ) limits.

Two further threats are worth flagging to guests directly. Feral dogs on beaches are a menace, disrupting the marine ecosystem by attacking intertidal life, migratory birds and, most severely, nesting turtles and their eggs. Never feed feral dogs or wild animals, and secure food waste. Invasive species, spreading mainly through global shipping via ballast water and hull biofouling, can choke waterways and smother reefs and mangroves. The water hyacinth, introduced as an ornamental in the colonial era, can double its numbers in about 12 days. The International Maritime Organization's Ballast Water Management Convention is the main international response.

Managing Expectations

A guide sets the tone for the whole group. Model these habits and explain them to guests gently, as part of the experience, rather than as a lecture. Responsible tourism works best when it is shown, not just told.

5. Quick-Reference Summary Table

A field cheat-sheet linking each coastal threat to what a responsible guide does about it.

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Beaches (litter)	Plastics, discarded fishing gear	Carry out all litter; refuse single-use plastic; join or organise plogging	Beach litter degrades ecosystems and entangles marine life
Beaches (vehicles)	Tyre tracks, compacted sand	Keep vehicles off the sand; walk; keep to designated paths	Driving crushes turtle nests and worsens erosion
Coral reefs	Anchors, snorkellers, divers	Use mooring buoys; never anchor on reef; look, don't touch	Anchors and touching both kill living coral
Illegal wildlife trade	Sea cucumbers, turtles, seahorses, shells	Never buy or collect wildlife products; report offences	Protected under the Wild Life (Protection) Act and CITES
Beaches (feral dogs)	Feral dog packs	Never feed dogs or wildlife; secure food waste	Dogs are a leading cause of nesting-turtle egg loss
Waterways (invasive species)	Water hyacinth, ballast-borne species	Don't move plants, animals or water between water bodies	Ballast water is regulated by the IMO's BWM Convention
Coastal construction	Cleared mangroves, levelled dunes	Choose low-impact, RT-certified stays; respect CRZ	CRZ rules limit construction in sensitive coastal areas
RT / Blue Flag destinations	RT-designated sites, Blue Flag beaches	Steer visitors towards certified, low-impact destinations	Kerala's RT Mission is a globally recognised model

6. Chapter Glossary

- **Responsible Tourism (RT):** tourism that makes a place better to live in and to visit, balancing economic, social and environmental responsibilities.
- **Triple bottom line:** the three linked responsibilities of RT - economic, social and environmental.

- **Eco-friendly tourism:** travel that minimises environmental impact and conserves ecosystems and local economies.
- **Blue Flag:** a global eco-label (33 criteria) awarded by the Foundation for Environmental Education to clean, safe, well-managed beaches.
- **Plogging:** picking up litter while jogging - a simple way to keep beaches clean.
- **Kudumbashree:** Kerala's women-centred community network, widely used to route tourism income to local families.
- **Coastal Regulation Zone (CRZ):** India's rules limiting construction and activity along the shoreline to protect coastal ecosystems.
- **WPA Schedules I & II:** the highest-protection lists of the Wild Life (Protection) Act, 1972, covering many marine species.
- **CITES / CMS:** international conventions controlling trade in endangered species, and protecting migratory species.
- **Ballast water:** water carried by ships for stability - a major pathway for invasive marine species; regulated by the IMO's BWM Convention.

7. Sources and Further Reading

- Kerala Tourism - Responsible Tourism (keralatourism.org/responsible-tourism) and the Kerala Responsible Tourism Mission.
- Foundation for Environmental Education (FEE) - Blue Flag (blueflag.global) for beach certification and criteria.
- International Maritime Organization (IMO) - the Ballast Water Management (BWM) Convention.
- Wild Life (Protection) Act, 1972; CITES; and the Convention on Migratory Species (CMS) for the legal framework protecting marine species.

Note: tourism designations, the Blue Flag list and CRZ rules change over time- refresh these at each edition.

CHAPTER 11

KERALA TOURISM AND SCUBA DIVING

An Emerging Frontier in Marine Adventure Tourism

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> ***How to Use This Chapter:*** *SCUBA diving is Kerala's newest and least-known tourism product of which most guests have no idea it exists here at all. This chapter gives you the bigger picture of Kerala's tourism growth and how marine adventure tourism fits into it, the diving sites that already operate, how a dive centre actually runs a trip, and the sustainable-management principles that can keep this young industry from repeating the mistakes seen elsewhere. Use it to answer the question guests increasingly ask on the coast: 'Can you dive here?'*

In This Chapter

1. Introduction & Coastal Context

Kerala, popularly known as God's Own Country, is one of India's premier tourism destinations, recognised globally for its remarkable natural beauty, cultural heritage, and responsible tourism initiatives. Located along the south-western coast of India, the state offers an exceptional diversity of tourism products including beaches, backwaters, hill stations, wildlife sanctuaries, heritage destinations, Ayurveda and wellness centres, and vibrant cultural traditions. The state's tropical climate, high literacy, relatively clean environment, and warm hospitality have established Kerala as a year-round destination for both domestic and international visitors.

Tourism is a major contributor to Kerala's economy, generating employment and supporting several allied sectors. In 2025, Kerala recorded its highest-ever tourist arrival with 25.88 million visitors, comprising 25.06 million domestic tourists and 0.82 million international tourists, an overall increase of nearly 2.9 million visitors over 2024. Domestic tourist arrivals increased by 12.46%, while foreign tourist arrivals increased by 11.3% compared to the previous year. Idukki recorded the highest tourist footfall (4.68 million), followed by Ernakulam, Thiruvananthapuram, Thrissur, Wayanad, and Kozhikode.

Kerala has successfully diversified its tourism portfolio by promoting heritage tourism, ecotourism, backwater and houseboat tourism, Ayurveda and wellness tourism, monsoon tourism, cultural tourism, and more recently, adventure tourism. Adventure tourism has emerged as one of the fastest-growing segments worldwide, driven by increasing demand for nature-based experiences that combine recreation with exploration. Among the various adventure activities promoted in Kerala, marine-based tourism offers considerable untapped potential owing to the state's extensive coastline and rich coastal ecosystems.

Stretching over approximately 590 km along the Arabian Sea, Kerala possesses numerous beaches, estuaries, lagoons, rocky shores, offshore reefs, and backwater systems that support diverse water-based recreational activities. Popular destinations such as Kovalam, Varkala, Bekal, and Cherai already attract visitors for surfing, kayaking, sailing, stand-up paddleboarding, parasailing, and houseboat tourism. Within this expanding marine tourism sector, SCUBA diving is increasingly gaining recognition as a specialised form of adventure tourism capable of attracting both domestic and international visitors seeking unique underwater experiences.

Unlike the coral reef ecosystems of Lakshadweep and the Andaman and Nicobar Islands, Kerala's underwater environment is characterised predominantly by rocky reefs, shipwreck sites, artificial reefs, and occasional hard coral outgrowths. These habitats support a rich assemblage of reef fishes, nudibranchs, echinoderms, crustaceans, sponges, octocorals, and other marine invertebrates, making them attractive destinations for recreational diving, underwater photography, marine biodiversity studies, and citizen science programmes. Although still at a nascent stage, SCUBA diving has considerable potential to become an important component of Kerala's sustainable coastal tourism strategy.

SCUBA dives in rocky reefs

2. Core Concepts & Environmental Dynamics

Adventure Tourism and SCUBA Diving

Adventure tourism is defined as travel involving physical activity, interaction with natural environments, and cultural exchange, often incorporating elements of exploration, challenge, and learning. According to global tourism trends, adventure tourism is among the fastest-growing sectors of the tourism industry, driven by increasing interest in authentic and environmentally responsible travel experiences.

SCUBA (Self-Contained Underwater Breathing Apparatus) diving represents one of the most popular marine adventure activities worldwide. It enables divers to explore underwater ecosystems while simultaneously promoting awareness of marine biodiversity and conservation. Modern recreational diving is supported by internationally recognised certification agencies such as the Professional Association of Diving Instructors (PADI) and Scuba Schools International (SSI), which maintain uniform standards for diver training, equipment safety, and operational procedures.

Netrani dive site with tourist boat

Globally, SCUBA diving contributes significantly to coastal economies by generating employment opportunities for dive instructors, boat operators, equipment suppliers, accommodation providers, and local communities. In addition to its economic benefits, diving tourism increasingly supports marine conservation through reef monitoring, underwater clean-up campaigns, citizen science initiatives, and environmental education programmes. Kerala possesses several advantages for developing SCUBA diving tourism: the state's warm tropical waters, diverse rocky reef habitats, and accessibility from major cities provide favourable conditions for recreational diving. Unlike destinations that rely solely on coral reefs, Kerala can develop a distinctive niche centred on rocky reef biodiversity, wreck diving, and underwater macro photography.

How a Dive Centre Runs a Trip

Most dive operators in Kerala currently follow internationally accepted operational standards established by agencies such as PADI and SSI. These centres cater to both beginners and experienced divers through a variety of programmes. The most popular activity is the Discover SCUBA Diving (DSD) programme, commonly known as 'Try Dives', designed for individuals with no previous diving experience. Participants receive a short theoretical orientation followed by closely supervised underwater experiences at shallow depths.

Certified divers can participate in boat dives, shore dives, fun dives, wreck dives, night dives, and underwater photography dives, depending on local conditions and diver qualifications. Several operators also offer internationally recognised certification courses ranging from Open Water Diver (up to 18 m depth) to Advanced Open Water (up to 30 m depth), Rescue Diver, and selected specialty courses such as the deep-diving speciality (up to 40 m depth). Before every dive, participants undergo equipment familiarisation, safety briefings, buddy checks, and underwater communication training. Emergency oxygen kits, first-aid equipment, communication devices, and trained dive professionals accompany all diving operations. As SCUBA diving is a physically demanding activity, participants must satisfy prescribed health requirements, and a signed undertaking confirming physical fitness is mandatory before any diving activity. Many centres also provide snorkelling and skin-diving programmes for non-certified visitors, allowing tourists to experience Kerala's shallow marine

ecosystems without formal SCUBA certification, often serving as an entry point for future recreational divers.

3. Spotlight Series: Flagship Species / Case Studies

- **Kovalam** *(Thiruvananthapuram)*

    - **Ecological Narrative:** Kovalam offers offshore rocky reefs, moderate water depths, and relatively clear post-monsoon waters, providing suitable conditions for Discover SCUBA Diving, Open Water training, and recreational dives. The area supports colourful reef fishes, sea stars, sea cucumbers, nudibranchs, octopuses, and occasional coral colonies.
    - **Status & Season:** The most established of Kerala's dive sites, though operations remain small-scale compared to Goa or Karnataka; best dived October to February when the sea is calmer and visibility improves after the monsoon.

SCUBA diving at Kovalam site

- **Kochi** *(wreck and artificial reef diving)*

    - **Ecological Narrative:** Kochi has emerged as another important diving destination, where artificial reef structures and nearby shipwrecks provide opportunities for recreational and wreck diving. The surrounding marine environment supports a variety of reef-associated organisms and offers excellent opportunities for underwater photography.
    - **Status & Significance:** A genuine point of differentiation for Kerala within Indian diving tourism, since wreck diving is a specialised niche few other Indian destinations offer at this accessibility.
- **Rocky Reef Macro Life** *(nudibranchs, sea slugs and echinoderms)*

- **Ecological Narrative:** Because Kerala lacks the extensive coral reef systems of Lakshadweep or the Andaman and Nicobar Islands, its underwater identity rests instead on rocky reefs, boulder fields, and the rich assemblage of invertebrates that colonise them: reef fishes, nudibranchs, echinoderms, crustaceans, sponges and octocorals.
- **Guiding Significance:** This macro-life niche is precisely what lets Kerala differentiate itself: a conservation- and photography-oriented diving identity built on rocky-reef biodiversity rather than competing directly with India's coral-reef destinations.

Sea slug observed in rocky reefs

Beyond these flagship sites, Varkala (Thiruvananthapuram) offers rocky reef habitats interspersed with lateritic formations and supports increasing interest in recreational diving, although operations remain limited. Munambam and Cherai in Ernakulam, as well as Thikkodi in Kozhikode, possess suitable sites that could be developed for introductory diving programmes and marine awareness activities. Further offshore, submerged rocky reefs, boulder fields, and isolated reef patches along the Kerala coast possess considerable potential for specialised ecological diving and scientific tourism, though many of these areas remain largely unexplored and would need detailed ecological assessment before development.

4. Practical Toolkit for the Field

Where and When to Look

Kovalam is the most reliable starting point for a guest's first Kerala dive, with Kochi the best choice for wreck-diving interest. Varkala, Munambam, Cherai and Thikkodi are emerging

sites best framed as introductory or awareness experiences rather than established dive circuits. The best diving season generally extends from October to February, when sea conditions are relatively calm and underwater visibility is optimal.

Reading the Environment

Post-monsoon clarity is the single biggest factor in whether a dive is worthwhile, conditions improve markedly from October onward. A reputable operator will always run equipment familiarisation, a safety briefing, and buddy checks before any dive; a centre skipping these steps is a red flag worth steering guests away from.

Field Etiquette & Responsible Code of Conduct

Kerala is uniquely positioned to establish a sustainable diving industry by integrating environmental management into tourism planning from the initial stages of development. Experiences from established diving destinations, particularly Goa, demonstrate that rapid and unregulated expansion can lead to pollution, overcrowding, habitat degradation, declining visitor satisfaction, and conflicts among resource users, Kerala has the opportunity to avoid these challenges through proactive planning.

- Support operators who use permanent mooring buoys rather than anchoring directly on rocky reefs and benthic habitats.
- Insist on environmental briefings before every dive: proper buoyancy control, responsible underwater behaviour, and avoidance of touching marine organisms.
- Practise ethical underwater photography - no handling, chasing or baiting marine life for a shot.
- Choose operators who follow internationally accepted safety standards set by PADI, SSI, or equivalent organisations.
- Favour dive centres involved in reef monitoring, underwater clean-ups, or citizen science.This is where guest spending can directly support conservation.

Managing Expectations

SCUBA diving in Kerala remains at a nascent stage and is far less developed than in neighbouring Goa and Karnataka. Guests should be told plainly that Kerala does not offer the extensive coral reef systems of Lakshadweep or the Andaman and Nicobar Islands — what it offers instead is rocky reef biodiversity, wreck diving, and macro photography, which is a genuinely different (not lesser) experience, but one worth setting up honestly rather than over-promising.

5. Quick-Reference Summary Table

A one-glance guide to Kerala's SCUBA diving sites and what each offers.

Target Subject / Habitat	Primary Indicator / Key Species	Operational Field Tip	The One Fact to Remember
Kovalam (Thiruvananthapuram)	Reef fishes, sea stars, sea cucumbers, nudibranchs, octopuses	Book Discover SCUBA Diving or Open Water training here first	Kerala's most established and best-known dive site

Kochi	Artificial reef structures, shipwrecks	Recommend to guests specifically interested in wreck diving	A genuine point of difference from India's coral-reef destinations
Varkala	Rocky reef and lateritic formations	Frame as an emerging, still-limited option	Growing interest but few established operators
Munambam, Cherai & Thikkodi	Introductory dive and marine-awareness sites	Best suited to non-certified, first-time visitors	Potential sites for future development, not yet flagship destinations
Best diving season (all sites)	Post-monsoon water clarity	Recommend October–February for bookings	Sea conditions and visibility are calmest and clearest in this window

6. Chapter Glossary

- **SCUBA:** Self-Contained Underwater Breathing Apparatus - a portable, independent air supply that lets a diver breathe underwater without a surface connection.
- **PADI / SSI:** the Professional Association of Diving Instructors and Scuba Schools International - the two leading international agencies certifying recreational divers and dive training standards.
- **Discover SCUBA Diving (DSD):** an introductory 'try dive' programme for people with no previous diving experience, run under close supervision at shallow depth.
- **Open Water Diver:** the entry-level SCUBA certification, typically qualifying a diver to depths of about 18 m.
- **Buddy check:** a pre-dive safety routine in which two divers verify each other's equipment before entering the water.
- **Buoyancy control:** a diver's ability to stay neutrally suspended in water without touching the reef or seabed - central to reef-safe diving.
- **Mooring buoy:** a permanently anchored floating buoy that boats tie to instead of dropping an anchor, preventing anchor damage to reefs.
- **Carrying capacity:** the maximum number of divers or visitors a site can sustain without ecological or experience degradation.
- **Wreck diving:** recreational diving focused on exploring sunken ships or other submerged structures.
- **Blue economy:** economic activity built on the sustainable use of ocean and coastal resources, of which responsible dive tourism is one strand.

7. Sources and Further Reading

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Note: dive-site development, operator numbers and tourist arrival figures change quickly in this emerging sector - refresh at each edition.

Disclaimer:

The views expressed in this chapter are solely those of the author and do not necessarily represent the views of the affiliated institution, which bears no responsibility for the content. This chapter is intended only to promote awareness and interest in SCUBA diving and marine tourism; it is not a training or instructional manual for SCUBA diving, which should be undertaken only after proper training from a certified dive instructor.